SERVANTS OF MODERN INDUSTRY

MONSANTO PLASTICS

TODAY'S PRODUCTS...AND PLASTICS

NOT LONG AGO, nearly 200 businessmen in a wide range of industries were asked, "What qualities in plastics first interested you in this newest of fabricating materials?"

The replies, from men who *know* what happened to costs and sales when plastics gained a place in their products, include these typical comments:

"Eye appeal"
"Elimination of machine operation"
"Color fastness"
"Freedom from maintenance"
"No plating necessary"
"Close control of dimensions"
"Convenience in production"
"Cleanliness"
"Elimination of hand labor in finishing"
"Ease of obtaining standard parts in an irregular form"

Those qualities of plastics which are apparent to the customer in the *finished product* won the majority vote of approval. Among such reasons, all having a direct influence on retail sales, are these:

Appearance, finish, color or transparency, durability, strength, light weight, electric insulating qualities, heat insulating properties.

Production Advantages

Another group of replies deals with the element of production *inside the plant*, and includes such points as these:

Ease of manufacture, adaptability to varied uses, greater versatility allowed in product design, low first cost of materials, greater accuracy in finished parts.

Thus, it is apparent that these businessmen have found in plastics a type of material which adds sales advantages to their products while still in many cases effecting savings—often over other materials with less sales appeal.

Reading of the experience of these manufacturers, it is logical for you to ask:

"Just what are Plastics....

AN APT DEFINITION of plastics has been given by the head of Monsanto Plastics research, who said: "Plastics are materials that, while being processed, *can be pushed into almost any desired shape*—and, then *retain that shape.*"

Moldable When Softened

All plastics derive their usefulness from the fact that under certain conditions of softening—by solvents, by suspension in liquids or by application of heat—they become moldable to a desired shape which they retain.

Of course, even this is far from being a complete definition. Yet it accurately sums up the main advantages of plastics from a production standpoint. It explains why these materials, so hard and tough in their finished state, are named "plastics"... a word which commonly denotes softness and pliability.

"Plastics" a Broad Definition

The word covers a wide range of materials. In fact, rubber and glass are among the earliest of plastics —being formed easily into any desired shape during their processing, then retaining that shape after cooling. Due to the tremendous growth of newer and even more versatile materials, however, the word "plastics" now applies almost exclusively to the synthetic products of chemistry, which can be cast,

molded or pressed into an almost unlimited variety of shapes. No one has catalogued all the textures, colors and configurations that can be attained.

Cellulose Nitrate . . . Pioneer Plastic

The first plastic to gain wide commercial use was cellulose nitrate. Today, that same material in a more highly developed form still finds countless applications—but it has been joined by many other plastics, each with its specific advantages and distinctive chemical and physical characteristics. Additional plastics are being developed constantly to meet new uses—in fact, Monsanto Plastics Division now produces a whole family of new materials undreamed of just a few years ago, in addition to the plastics it has been producing for many years.

Five Groups of Plastics

Yet, new or old, all plastics can be grouped into five main divisions. The first are cellulose plastics, derived from cotton. In this division are found Monsanto Cellulose Acetate and Monsanto Cellulose Nitrate.

The second division is made up of plastics derived from organic raw materials. Monsanto Cast Phenolic Resin is such a material.

The third—vinyl plastics which are derived from acetylene, a product of limestone and coke.

Others are derived from animal matter and from inorganic raw materials . . . including casein, urea resin and vinyl acetals.

Regardless of its basic source, each of these synthetic plastic materials owes its existence to chemists who have converted raw materials into products of wide commercial possibilities.

How Plastics Can Serve You

If you are seeking added beauty, more color and permanent color, lighter weight, speed in production, a finish that is permanent and integral, better electrical insulation, warmth and pleasing touch in the material you use, durability, a finished product that is easy to clean, elimination of intricate assembling operations, transparency or opacity or translucence —then plastics are worthy of your careful study in their relation to *your* product.

Plastics on the March

The plastics industry deserves to be rated among the fastest growing in the world. Between the time this is written and the time you read it, you may mark it down as a certainty that several developments will have occurred—in the production of new materials, refinement of existing materials and improvement in methods of fabrication.

Considering this day-to-day progress, you might say: "I will wait for more of these future developments to come along, before I look into plastics for my product." That would be economicallydangerous! *Today's* plastics are at a high degree of development. And no forward-looking industry dares ignore plastics, so long as it includes men who *will* study and use them to gain leadership over competition.

Materials for Many Uses

The range of Monsanto Plastics includes materials usable in almost every industry—Monsanto Cellulose Acetate, Monsanto Cellulose Nitrate, Monsanto Cast Phenolic Resin, Monsanto Polystyrene molding compound, a group of new Vinyl Acetal Resins, Vue-Pak for transparent packages.

Of these plastics, the widest commercial uses are made of cellulose acetate, cellulose nitrate, cast phenolic resin and Vue-Pak, and later detailed discussion of materials will be limited to these, although the others are available and doubtless will find equally wide commercial application in time.

Supplied in Many Forms

Monsanto Plastics are supplied to fabricators and manufacturers in a great variety of commercially usable forms—standard sheets, continuous rolls, rods, tubes, molding compounds and slabs and special shapes—thus, there is available a variety of materials.

FIFTY YEARS OF DEVELOPMENT

SO MUCH HAS BEEN SAID AND WRITTEN in recent years about plastics development, and these materials have gained such general use during the last decade, that it is often assumed plastics are an "infant industry."

Far from it!

There is evidence of early plastics fabrication in the time of the Roman Empire, with records of a flexible glass-like material.

For all practical purposes, however, it may be declared that the present-day plastics industry was launched more than fifty years ago—which still is about forty years earlier than the average citizen realizes.

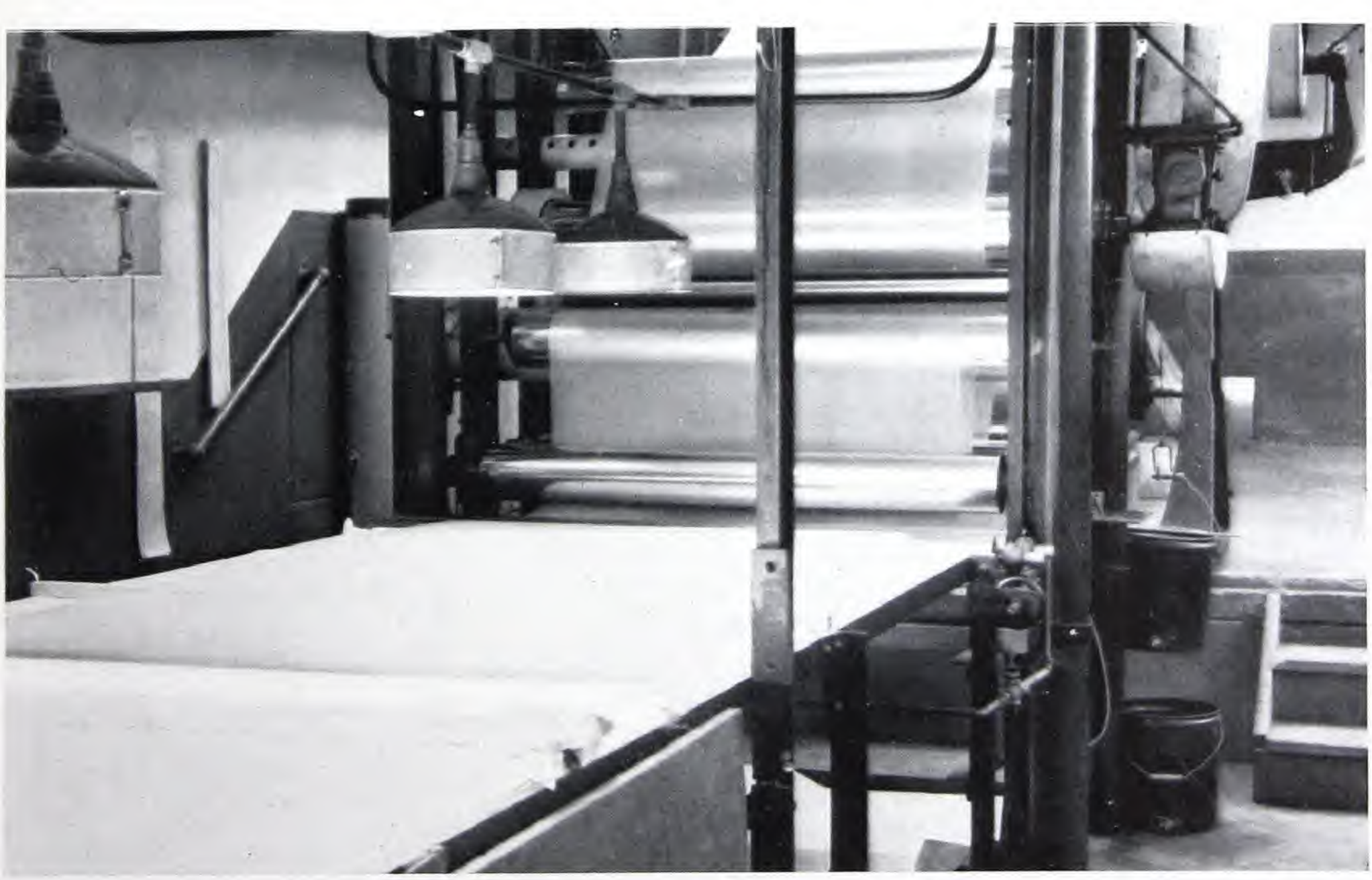
Since the Plastics Division of the Monsanto Chemical Company had its origin in these "dark ages" of the industry in the 1880's, the record of its own growth really parallels the history of plastics in general.

In 1892, a modest little plant was operating at Newburyport, Massachusetts . . . the embryonic Fiberloid Corporation. Later it was to become one of the leaders in the plastics industry and, early in 1938, was to unite with the Monsanto Chemical Company as Monsanto's Plastic Division.

Research Brings Progress

The year 1904 found the lusty young company packing up, bag-and-baggage, and moving to a new plant it had built on the banks of the Chicopee River, a few miles east of the center of Springfield, Massachusetts.

There it settled, confident that it had ample room for future growth. That belief seems somewhat humorous today, when the original Indian Orchard plant is seen nested in the broad sweep of buildings which today comprise the Plastics Division. From a



A view of the Monsanto process for production of transparent safety glass plastic in continuous rolls.

few hundred feet of floor space in 1904, the plant today has grown to cover more than fifty acres of floor space in more than fifty buildings.

And Then — Safety Glass!

It was here that cellulose nitrate, still a major staple among plastics, ceased to become the company's sole product and became one of a *family* of plastics products. And, from this plant on the banks of the Chicopee, came one of the major developments in all plastics history—the perfection of cellulose acetate in *continuous rolls* for automobile safety glass.

It required years of research, and the development of new machinery to produce cellulose acetate transparent sheeting in the form of continuous rolls, like newsprint. But the result is a process regarded as one of the premier processing methods of the plastics industry.

A Contribution to Every Motorist

Had the motor car industry been forced to rely on its safety glass plastic being produced only in standard-size sheets, with accompanying wastage of material, it is doubtful whether the protection afforded by safety glass would be so universal today. Certainly, it would have continued to add many dollars to the price of automobiles over today's low cost.

This is not by any means the only "first." So far as all obtainable records show, the first fountain pens of plastics were fabricated from material produced in the Springfield plant. Likewise, this plant originated the application of phenolic resin castings for radio cabinets—and this gem-like material almost instantly won a major place for itself in this application.

One of the most exacting requirements for any plastic is in its use for transparent drawing instruments. In such products, there must be no shrinkage or distortion. Ninety per cent of the plastic materials for such instruments is produced by Monsanto's Plastics Division.

A Fundamental Policy

Long ago the organization established the major policy of producing only plastic materials from which others can fabricate finished products, and to devote every research and production energy to this purpose.

This means that Monsanto Plastics are not in competition with the fabricator or manufacturer who produces finished articles from the basic plastic materials he buys from Monsanto. These are plastics for fabrication *by the trade* . . . not finished plastics articles to be sold to the ultimate consumer.

One Main Objective

None of Monsanto Plastics' research or production energies are diverted from the main objective of producing the finest quality plastics materials possible—and the wisdom of this policy is shown by the long list of customers, both custom fabricators and nationally known manufacturers, who have dealt *exclusively* for many years with this plant.

BELOW: General view of Monsanto Chemical Company, Plastics Division, plant at Springfield, Massachusetts.
INSET: Partial view of new plant for production of vinyl acetals, which adjoins buildings shown in large picture.

Such has been the growth from the small plant in Newburyport, to one of the largest plants in the world devoted exclusively to production of plastics.

Development has followed development as surely as one note follows another in a symphony. And it has been progress so swift that it could be *seen* and *measured* . . . from the early beginning with one plastic material to production of materials in almost universal use in countless industries, all within a scant fifty years.

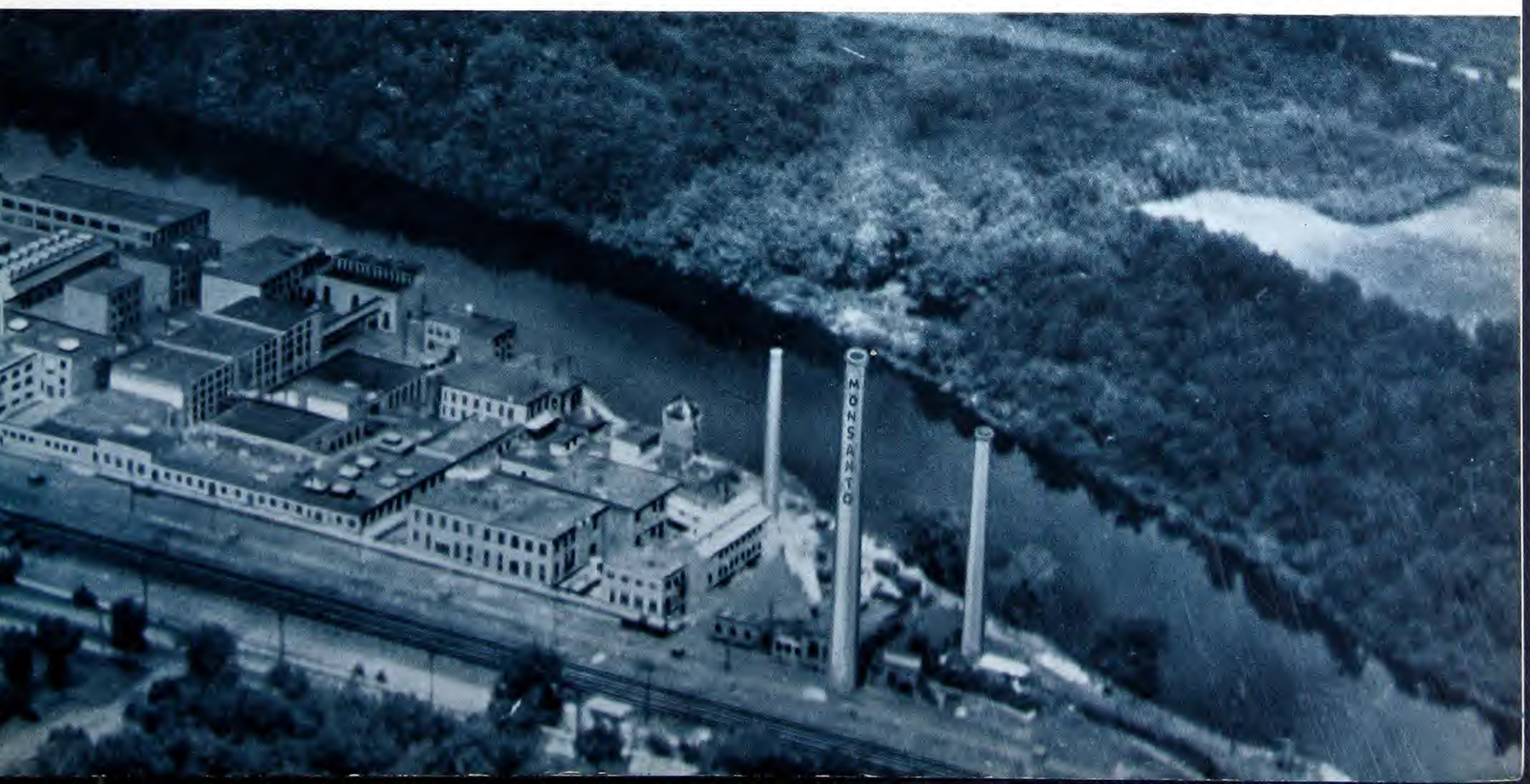
In 1938, this plant became one of the twelve chemical production units in America and Great Britain that form the Monsanto Chemical Company.

A Record of Growth

While this sketches the growth of only one company in the plastics industry, its development has been in step with the constant expansion of the industry as a whole. Others have made equally notable advancements in the production of materials and the perfection of processes, at the same time the Plastics Division was pioneering the developments outlined here.

It has been through versatility in materials and methods that the plastics industry has grown. Well over 100,000,000 pounds of plastics are produced yearly by this industry. It is estimated that the value of fabricated articles exceeds $150,000,000 annually —and each year's total in pounds and dollars grows larger as additional materials and uses are developed. Within six years the industry has increased its volume 50 per cent.

ABOVE: Monsanto Plastics molding compounds, in granules or slabs, provide an infinite range of solid colors or mottles.



Monsanto Plastics are used in golf club faces and for covering club shafts, for the colorful new Plas-tees, and for covering and decorating rackets.

MONSANTO PLASTICS

—their characteristics and advantages

IT HAS BEEN SAID that "plastics is a drug store business," meaning that the plastics manufacturer must compound his materials like druggists' prescriptions, to meet the individual requirement.

Although new formulas are not required in each new use of plastics, the majority of applications do call for materials that are custom-compounded to meet individual needs.

Basically, however, all the needs for plastics are met by a comparatively few materials—adjustments in formulas or variations in form of the material multiplying into a list bewilderingly long.

Designed for Sales Appeal

Of the basic plastics, Monsanto has chosen to concentrate on the production of those most closely linked with the *appearance appeal* in finished products. In other words, Monsanto Plastics include those materials most readily usable by manufacturers in increasing sales appeal.

These plastics are divided into two groups—thermoplastic and thermosetting materials.

What are Thermoplastics?

Thermoplastic materials are plastics that can be formed into desired shape under heat and pressure—

Spectacle frames, sun glasses and goggles gain added beauty and utility from Monsanto Plastics. Many of these complicated forms are made from a single molding injection.

that derive their rigidity by chilling while still in the mold—and that can be remolded into any other desired shape at any time by being subjected to the same conditions of heat and pressure.

Of course, no everyday use of a finished plastic article ever will bring it into contact with the high temperatures of the molding process, so this cannot be counted as a disadvantage. The practical advantages are that thermoplastics lend themselves to a fast cycle of molding or shaping, and offer production economies since rejects can be re-molded.

Thermosetting Materials

Thermosetting materials are those plastics which acquire infusibility under heat and pressure. Afterward, they are practically unaffected by high temperatures, and cannot be re-molded. While being fabricated, they require a short dwell in the mold—from one to fifteen minutes in most cases. This permits the chemical hardening reaction to take place. Unlike thermoplastics, which cool in the mold, thermosetting materials leave the mold at high temperature.

Different problems call for different materials. In many cases, thermosetting materials meet the requirements better than thermoplastics . . . in other cases, the reverse is true. Always, in plastics, the application determines the material.

The Monsanto Cellulose Acetate and Monsanto Cellulose Nitrate are thermoplastics; Monsanto Cast Phenolic Resin is a thermosetting material.

Three Monsanto Plastics in one radio—grille and knobs of cellulose acetate molding compound, dial crystal of clear cellulose acetate, cabinet of cast phenolic resin.

MONSANTO CELLULOSE ACETATE

SUPPLIED in sheets, rods, tubes, continuous lengths and molding compounds, Monsanto Cellulose Acetate is one of the most versatile of all plastics.

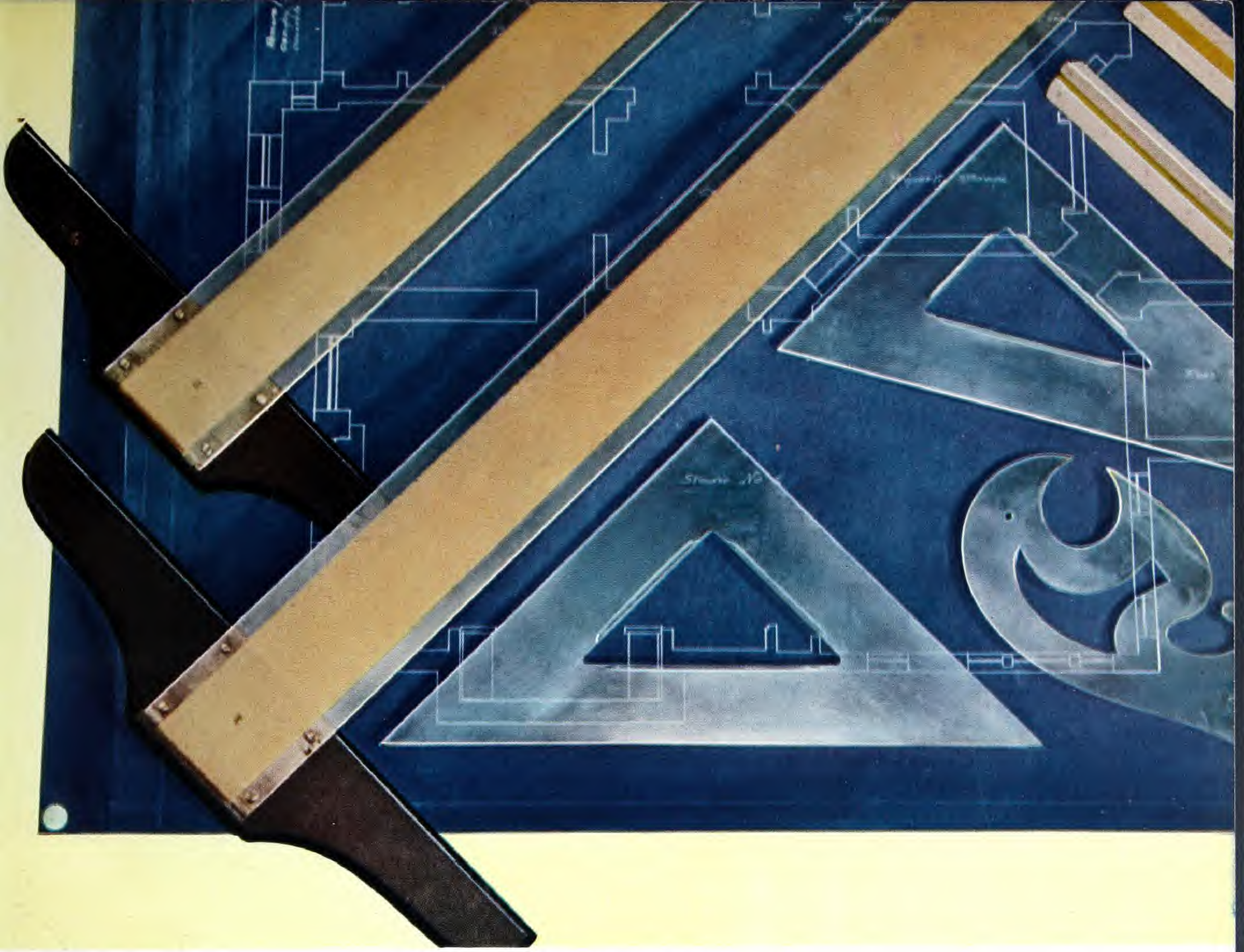
Infinite Range of Colors

Any color in the spectrum can be reproduced, either in solid colors or in a multitude of mottled or variegated tones. It can be fabricated into articles that are opaque, translucent or transparent.

Monsanto Cellulose Acetate is an excellent molding material—having toughness and resilience. These qualities are important in products having very thin walls or wherever freedom from brittleness is required.

Pleasing to the Touch

Ordinary temperatures up to approximately 150 degrees, Fahrenheit, do not affect products made of Monsanto Cellulose Acetate. It has low heat-conducting properties. This, combined with smooth finish, makes it desirable for use in products that come in contact with the skin.



Monsanto Plastics are used in the majority of drawing instruments, where flawless clarity and freedom from shrinkage or distortion are of primary importance.

Monsanto Cellulose Acetate is safe — rated by the Underwriters' Laboratory Re-examination Service in this manner: "Hazards of this product in use are judged to be small, and in storage somewhat less than would be presented by common newsprint paper in the same form and quantity."

Quality is Safeguarded

Uniformity of Monsanto Cellulose Acetate is maintained through precise manufacturing processes. Accurate color matching is a major feature of Monsanto Plastics. Dyes and pigments are carefully selected and compounded to provide stability under all conditions of light and heat.

Aids Speedy Production

Monsanto Cellulose Acetate molding compound may be compression or injection molded (both processes being described on later pages). No chemical change is involved in the molding process, so there is no tie-up of production for curing. Trimmings can be remolded immediately with no waste.

The toughness, freedom from brittleness, exceptionally close grain and uniform texture of Monsanto Cellulose Acetate make it easy to machine with ordinary wood and metal-working tools.

Wherever eye-appeal is important, Monsanto Plastics make an important contribution. They are widely used in piano keys and for decorative effects on other musical instruments.

MONSANTO CELLULOSE NITRATE

AVAILABLE in sheets, rods and tubes. Monsanto Cellulose Nitrate is supplied in many colors or mottles. It has the characteristics of closely simulating ivory, amber, tortoise shell, semi-precious stones, wood grain and pearl.

Adaptable for Many Uses

Where flame-resistance is not a requirement, Monsanto Cellulose Nitrate is often preferred, due to its low cost, ease of fabrication and the remarkable effects achieved with it.

More than 4,000 colors, configurations and mottles are available in stock samples, and any additional effects can be matched.

Developed Through the Years

Cellulose Nitrate is a pioneer among plastics, and as a result of its long usage, many improvements have been made in its manufacture and in fabrication processes since it first found widespread commercial favor.

The long experience of Monsanto Plastics Division with this material (its first plastic) has developed a wealth of information on specialized applications which is available to all Monsanto Plastics customers.

Transparent Monsanto Cellulose Acetate molding compound is used in unbreakable crystals for watches, clocks and radio dials... gives new utility to oil cans by adding visibility.

MONSANTO CAST PHENOLIC RESIN

MONSANTO CAST PHENOLIC RESIN is a thermosetting material available in sheet, rod and tube form, as well as in special shapes.

Provides Rich, Clear Colors

It produces articles of remarkably light weight, hard and shock-resistant, non-inflammable and odorless. It takes high polish and has great dielectric strength. Colors and color combinations are limited only by the range of the spectrum.

Of all plastic materials, probably none equals cast phenolic resin in the jewel-like clarity of its colors. That is one reason why it is gaining such wide use in radio cabinets. One of the most striking results of the radio manufacturer's application of plastics has been the production of sets with Monsanto Cast Phenolic Resin cabinets, grilles made of a contrasting shade of Monsanto Cellulose Acetate molding compound, and crystal-clear dials of transparent Monsanto Cellulose Acetate sheets—three different applications of plastics in one finished product!

Handles Well in Production

In manufacturing operations, Monsanto Cast

Even at vacationtime, Monsanto Plastics are at work. They serve as transparent minnow traps, as colorful bobbers and lures and as parts of rods and reels.

Phenolic Resin is machined readily in a manner similar to brass or wood. It can be sawed easily; ordinary brass-drilling equipment operates perfectly; for threading, standard taps and dies may be used.

Monsanto Cast Phenolic Resin can be heated and shrunk on metal cores or inserts; machined to extremely close tolerances; may be engraved, carved, stamped or embossed. A brief immersion in hot oil makes the material readily formable.

Other Monsanto Plastics Products

Monsanto Plastics Division produces additional materials which are not dealt with in detail here. They include Monsanto Polystyrene molding compound and Polyvinyl Acetals.

Where an application calls for one of these materials, information will be supplied on request.

Transparent Vue-Pak

Monsanto Vue-Pak, the new transparent packaging material, is another product of Monsanto Plastics. Because its applications in the packaging field are so widespread, Vue-Pak is the subject of a separate catalogue which is available on request.

Supplied in any desired weight, Vue-Pak is available in sheets or continuous rolls. It fabricates readily into any practical shape . . . enabling the products packaged within it to exercise their full eye-and-sales-appeals in retail stores.

Safety and beauty are brought to the modern motor car by Monsanto Plastics . . . in safety glass and as colorful knobs, steering wheels and interior trim.

HOW PLASTICS ARE FABRICATED

USERS OF MONSANTO PLASTICS are divided into two important groups.

The largest is made up of custom or trade fabricators—firms which specialize in molding and fabricating plastics to the specifications of other companies which use them in finished products.

The second group is made up of proprietary fabricators—that is, companies that maintain their own fabricating departments and use the finished plastic articles in their own products.

Regardless of whether plastics are fabricated in a custom plant or in a manufacturer's own fabrication department, the fundamental processes are identical.

Compression Molding

The original molding process was compression molding, and it is widely used.

The most practical type of compression molding machine usually is a hydraulic press, which exerts an even pressure and closes as the molding granules or slab are reduced to the required plasticity.

While a pressure of 500 pounds per square inch is sufficient for compression molding purposes, the use of higher pressures to 3,000 pounds and more results in a quicker cycle with increased production. Thus the higher pressures are generally recommended.

Monsanto Vue-Pak, the new transparent packaging material, displays while it protects . . . puts every product into a showcase of its own.

Molds are heated usually by steam under 150 pounds pressure, with temperature carefully regulated to the level indicated by preliminary tests on each lot of plastics material.

Injection Molding

While a comparatively recent development in molding practice, injection molding has done much to revolutionize the plastics fabrication industry. It provides a speedier method than compression molding.

This is what happens in injection molding:

The plastic material is heated *outside* the mold itself. Then the proper amount of softened material is forced into the mold chamber. The mold, being cool, permits the material to harden, after which the finished piece automatically is ejected.

Often, injection machines have multiple-molds, so that more than one article can be formed on each injection.

In the main, it is considered sound practice to mold small, quantity-production pieces by the injection method, larger objects by compression.

Other Processes

There are variations in the fabricating process for each different plastic. Vue-Pak, for transparent boxes and packages, for example, is usually formed by pressure under low heat from the flat sheets, then cemented at the joints or welded by solvents.

As mentioned, cast phenolic resin can be formed after immersion in a hot oil bath. In many instances, it is supplied also in special shapes, conforming in dimensions to the finished article, and requiring only machining and polishing after it reaches the fabricator's hands.

THE SERVICE OF THE CUSTOM FABRICATOR

THERE IS A BUSINESS PARALLEL that well might be drawn between the plastics industry and the field of commercial printing.

Many manufacturers have found it unprofitable to maintain printing departments of their own, due to the high cost of presses, typesetting machines and similar equipment, as well as the expense of day-to-day operation. A minority, of course, have found such a company-maintained department profitable because of the volume of printing they require.

How the Comparison Applies

The same comparison may be made in plastics fabrication. It is expensive to install the original equipment needed for an efficient molding general fabrication plant—and it is impossible to economize by installing only a *part* of the equipment needed, since the services of the custom fabricator still are required to complete the production of the finished article.

Craftsmanship is Important

Beyond this, however, there is another important consideration that applies in all cases except where the manufacturer can staff a department of his own with experienced fabrication technicians. And that is the high degree of skillful craftsmanship that is concentrated into the custom fabrication plants throughout the country.

Despite all the research efforts of producers of plastic materials, the majority of new uses for plastics originates in the plants of custom fabricators.

Experience Plus Imagination

These men and their staffs live with plastics day in and day out. They know how to attain the best results from the highly technical processes which they have mastered, exhibiting a creative imagination which is an asset both to the manufacturer who uses their services and to the producers of plastics.

In the majority of instances, the custom fabricator is the logical answer to a manufacturer's needs. Such fabricators are well distributed, geographically.

Monsanto Plastics will be happy to supply the names of competent fabricators on request.

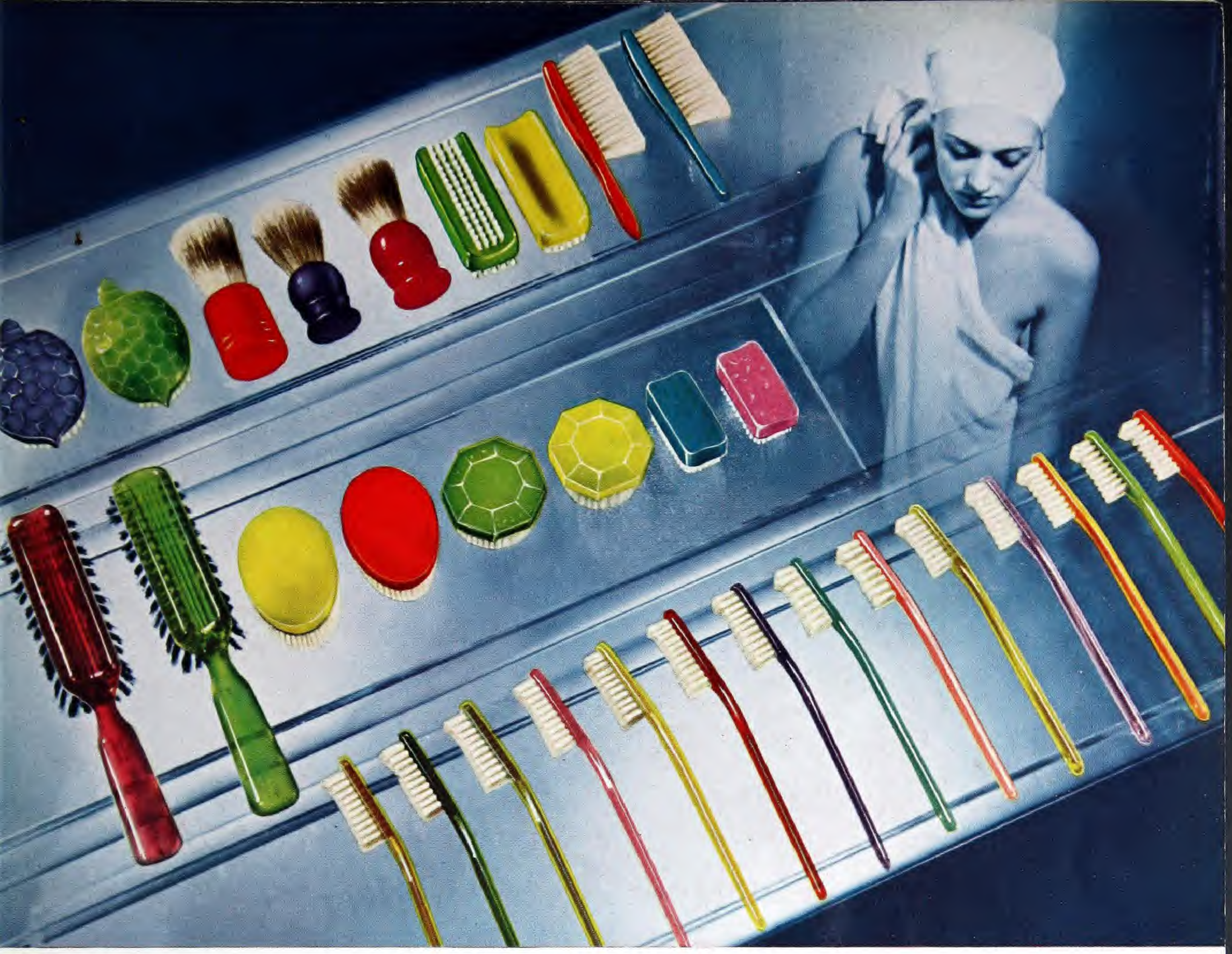
Style steps forth in plastics. Here are durable heel covers, solid heels, shoe forms, even shoe eyelets . . . of Monsanto Plastics in gay colors or lustrous black.

MONSANTO PLASTICS – SERVANTS OF MODERN INDUSTRY

WHEN YOU SPECIFY Monsanto Plastics, you automatically gain the benefit of more than fifty years' experience in the production of plastics.

These materials are backed by one of the most experienced research staffs in the industry, and are produced in one of the world's largest and most modern plastics plants. In the hands of skilled, experienced fabricators, Monsanto Plastics have proved their merits in winning outstanding awards in national and sectional competitions of the plastics industry.

RIGHT: Products made wholly or in part of Monsanto Plastics which won five awards in a national competition in the plastics industry.



Monsanto Plastics serve in the bathroom, as well as in every other room of the home. Millions of brushes gain added beauty through use of these colorful plastics.

APPLICATIONS

Any list of applications in which Monsanto Plastics are being used is bound to be only a *partial list*. Daily, additional uses appear — evidence that the scope of plastics is limited only by the imagination and ingenuity of the fabricators and manufacturers using these materials. The list that follows indicates such versatility.

(The abbreviations, made in such form to save space and make for easier reading, are CA — Cellulose Acetate; CN — Cellulose Nitrate; CP — Cast Phenolic Resin. These indicate the type of Monsanto Plastics used in each application.)

Accordion Buttons and Trim CN—CA

Adding Machine Buttons CN—CA

Advertising Buttons CN—CA

Advertising Novelties CN—CA

Airplane Windows and Wind Shields CA

Animated Cartoons CN—CA

Automobile Door Handles CA—CP

Automobile Glare Shields CN—CA

Automobile Instrument Board Lenses CA

Automobile Side Curtains CN—CA

Automobile Lamp Reflectors CA

Automobile License Holders CN—CA

Automobile Stop Lights CN—CA

Automobile Tail Lights CN—CA

Automobile Visors CN—CA

Automobile Directional Signals CA

Baby Carriage Handles & Windows CA—CN

Badges CA—CN

APPLICATIONS (Continued)

Bag Frames CA—CN
Banjo Picks CN—CA
Barometer Cases CP
Bathroom Fixtures CN—CA
Beads CP—CA
Belting (interlinings) CN
Billfolds CA—CN
Bird Cages CA
Blotter Covers CN—CA
Bookmarks CA—CN
Box Covers CA
Boxes—Transparent (Vue-Pak) CA
Opaque CP
Bracelets CP—CA
Brushes CN—CA—CP
Brush Backs (Hair) CN—CA—CP
Buckles (Belt) CA—CN—CP
Buffers CN—CP
Buttons CA—CP
Batons CN—CA

Calculating Machine Window CN—CA
Calendars CN—CA
Campaign Buttons CN—CA
Cap Fronts CN—CA
Cash Register Buttons CA—CN
Card Cases CN—CA
Clock Cases CP
Clock Dials and Crystals CN—CA
Clothing Buttons CA—CP
Combs CA—CN
Cue Tips CA—CP
Cutlery Handles CN—CA—CP
Collar Buttons CA

Dental Plates CN
Desk Sets CP
Dials CA
Dice CP
Dictaphone Ear Cups CA
Dictagraph Mouthpieces CA
Display Forms CA
Dominoes CN—CA—CP
Display Boxes CA—CP
Drafting Instruments CN
Drawer Pulls CP
Dress Buckles & Buttons CA—CP
Drum Shells CN
Drum Sticks CN
Electric Light Shade Deflectors CA
Envelope Sealing Machine Water Holder CN—CA
Envelope Windows CA
Envelopes, transparent CA
Eyeshades CN—CA

Fasteners—Snap CA
Films CA
Fish Traps and Lures CA—CP
Florists' Tags CA
Food Covers CA
Fountain Pens & Pencils CN—CP—CA

Games CN—CA—CP
Garters, Buckles & Slides CA
Gauge Windows CA
Goggles CN—CA
Golf Club Handle Coverings CN
Golf Inserts CN
Golf Club Facings CN
Golf Ferrules CN—CA
Guitar Bindings CN—CA

Hair Ornaments CA
Hat Creasers CA

Index Forms CN—CA
Inlaid Work on Billiard Tables CN
Inlaid Work on Musical Instruments CN
Inlaid Work on Store Window Panels CN—CA

Jewelry Novelties CN—CA—CP

Key Packs CN—CA

Labels CN—CA
Lithographs CN—CA

Machine Buttons CA
Mah-Jongg Tiles and Racks CP
Mail Box Windows CN—CA
Mandolin Buttons CN—CA
Mandolin Picks CN—CA
Manicure Fittings CN—CA—CP
Map Rings CN—CA
Medallions CN
Menu Cards CN—CA
Millinery Ornaments CN—CA—CP
Minnow Traps CA
Mirror Beading to hold glass CN—CA
Mirrors CA—CN
Motion Pictures CA

Notebook Covers CA

Optical Frames CN—CA

Paint Color Cards CN—CA
Pass Books CN—CA
Pencils CN—CA—CP
Pencil Sharpeners CN—CP
Phonograph Decorative Trim CA—CP
Phonograph Records CA
Photographs CN
Photo Mounts CA
Piano Keys CN—CA
Picture Frames CN—CA
Picture Frame Windows CN—CA
Pocketbooks CN—CA
Pocket Combs CA
Pocketknife Handles CN—CA
Poker Chips CP
Poultry Leg Bands CN
Powder Puff Boxes CA—CN
Price Tags CN—CA
Plastic Book Binding CA—CN

Radio Cabinets CP
Radio Dials CA
Radio Knobs CP—CA
Rattles CN
Razor Handles CN—CA
Reel Handles CA—CP
Refrigerator Hinge Gaskets CN—CA
Refrigerator Linings CA
Rubber Stamp Handles CP
Rules CN

Safety Glass CA
Saxophone Keys CA
Shaving Brush Handles CP—CN
Shoe Eyelets CN
Shoe Forms CN—CA
Shoe Hooks CN
Shoe Interlinings CN
Shoe Lace Tips CN—CA
Shoe Lasts CN—CA
Signs CN—CA
Slide Rules CN
Stencils CA—CN
Surgical Instruments CA—CN
Switch Plates CA
Sword Handles CN—CA

Table Cutlery CN—CA—CP
Thermometer Bases CP
Toilet Seats CN—CA
Toiletware CN—CP—CA
Tool Handles CN—CA—CP
Toothbrush Handles CN—CA
Toothbrush Holders CN
Towel Bars CN—CA
Towel Racks CN
Toys CN—CP—CA
Traffic Sign Letters CA
Traffic Signal Lights CA
Transparent Windows CA—CN
Trophy Bases CP
Typewriter Keys CN—CA

Umbrella Handles CN—CA—CP
Ukulele Pegs CN

Vanity Cases CN—CA—CP

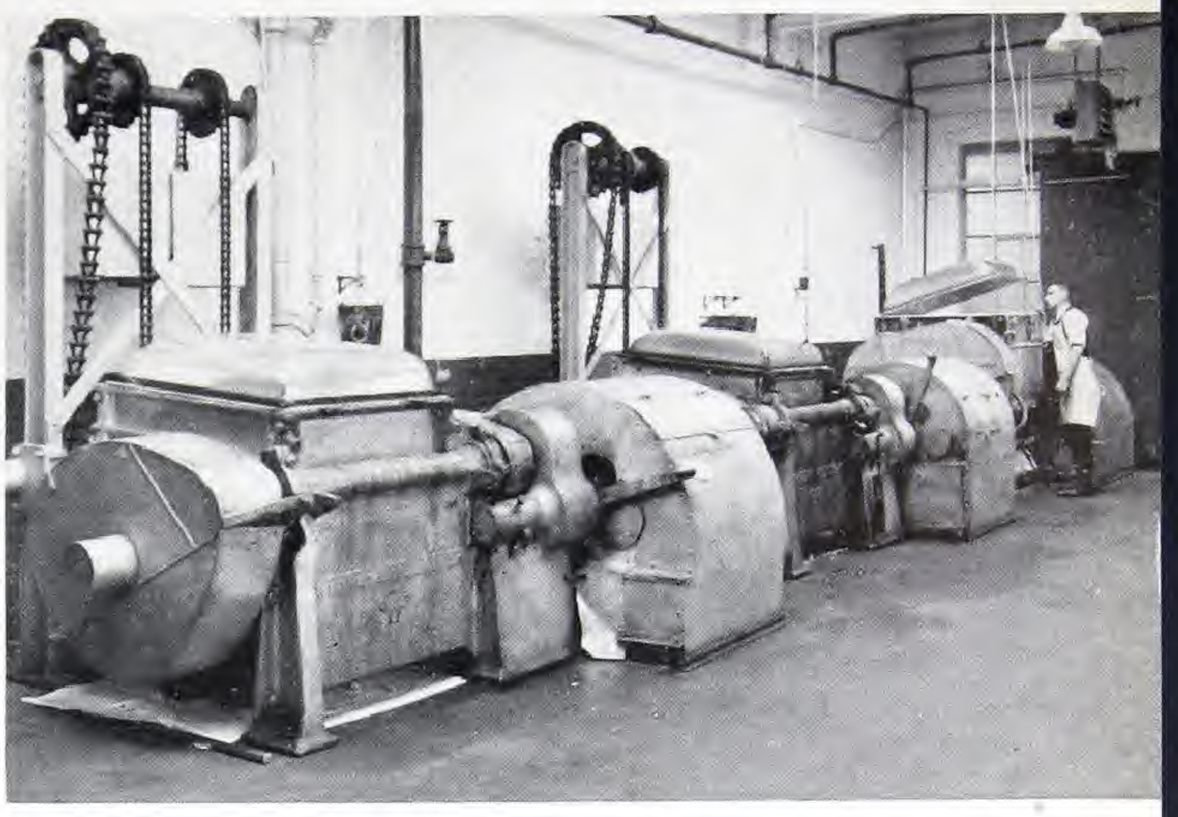
Wallets CN—CA
Watch Crystals CN—CA
Whisk Broom Holders CN—CA
Wind Shields CA
Wood Heel Covers CN
Writing Pads CN

X-Ray Mounts CA

SKILLED HANDS AND MODERN EQUIPMENT

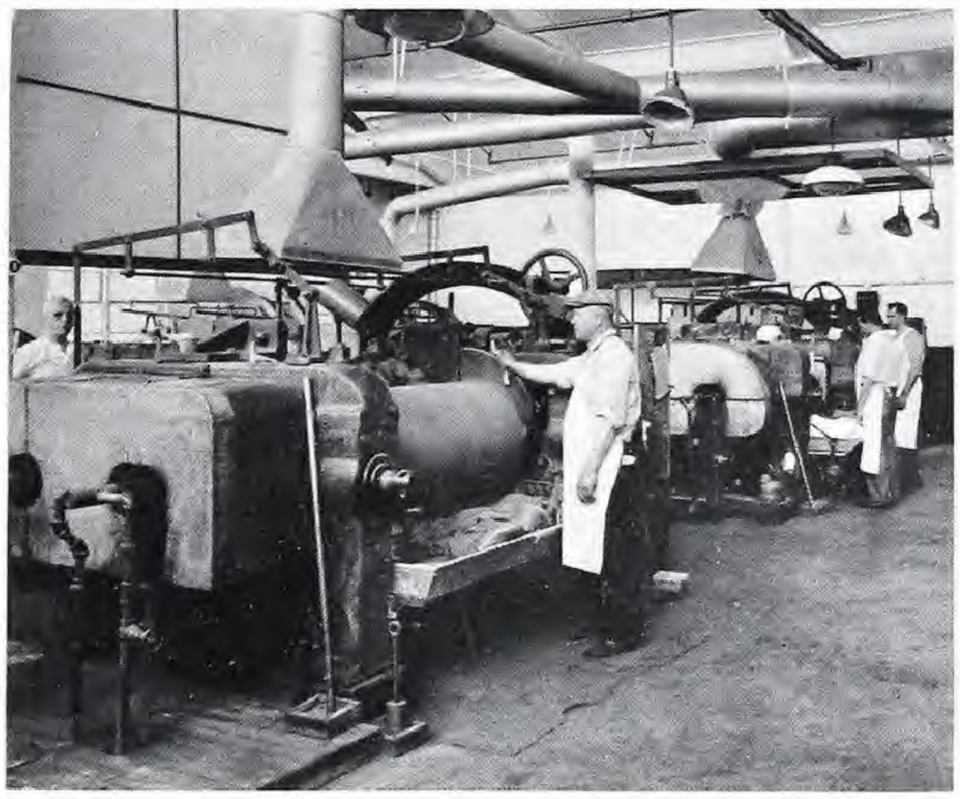
One of the Cellulose Dryers... Here purified cellulose is first dehydrated, preparatory to the many steps that will transform it into plastics.

Acid Extractor . . . After being combined with acid, the converted cellulose is whirled in a centrifugal wringer to remove excess liquid.

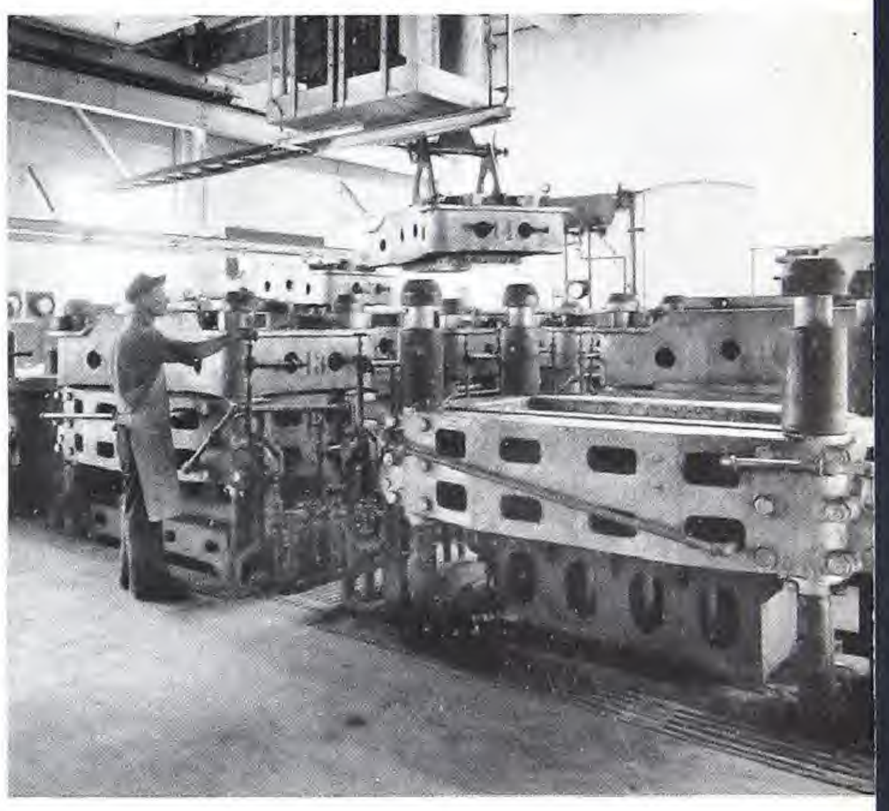


Partial View of Preliminary Mixing Department . . . Converted cellulose, plasticizer and solvents are mixed into a homogeneous mass. This is one of the most important stages of the process, since thorough mixing is essential to the quality of the finished plastic.

Dumping Mixture of Plastic . . . The converted cellulose has been dissolved completely in plasticizer and solvents and looks like dough.



Partial View, Roll Room . . . Here the plastic materials are kneaded by rolling into a solid mass. Color is added at this stage of the process.



General View, Cake Press Department... Here the material, after being rolled, is pressed into cakes for further processing.

Partial View, Sheeting Room . . . Baked cakes of plastic are secured to sheeting machines, and under tremendous power, sheets are cut from the cake in thicknesses from .003" up to ½" and over.

Partial View, Press Polish Department . . . Seasoned sheets of plastics are interlayed between polishing plates. Heat and high pressure are applied, then sheets are chilled to create permanent finishes.

Partial View, Sheet Inspection Department . . . Rigid inspections of all Monsanto Plastics assure uniformly high quality. In the sheet department, for example, every piece of material is scanned by experts.

How Plastics Rods are Made . . . Here prepared plastic is being extruded through nozzles under hydraulic pressure to produce rods and tubes in any desired length.

The color, lustre and pleasing warmth to the touch that Monsanto Plastics contribute, add much to the sales appeal of fountain pens and pencils.

YOUR PRODUCT....AND PLASTICS

It has been said if you even *suspect* that plastics might be able to make a contribution to your product, the probabilities are that investigation will show many ways in which these materials can increase sales appeal, aid in reducing production costs.

Of necessity, this discussion has dealt with plastics in general terms. Because of the multitude of industries in which Monsanto Plastics can serve, it has been impossible to point out all the applications of these wonder-working materials in the specific terms that you might have wished.

Your product may be different from others, even in its own field. Otherwise, it might not survive modern day competition. In order to see just where and how plastics might make their contribution, nothing less than individual analysis is satisfactory.

For that reason, Monsanto Plastics Division offers you the assistance of its experienced staff on any question related to use of plastics.

Inquire of Monsanto Chemical Company, Plastics Division, Springfield, Massachusetts, or any district office.

MONSANTO
CELLULOSE ACETATE
MOLDING COMPOUND

DATA SHEET

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION

SPRINGFIELD · MASSACHUSETTS

TABLE OF CONTENTS

TECHNICAL DATA

I FOREWORD

Monsanto Cellulose Acetate molding compound is a permanently thermoplastic material; "thermoplastic" meaning that the material requires heat to shape and chilling to set it in the desired form. The process has no chemical effect upon the material. Since molding of this material effects only a physical change, it can be remolded by the same process . . . an important saving since rejects can be molded again into perfect pieces.

Various formulae of Monsanto Cellulose Acetate molding compound are supplied—each having a definite thermal region in which it becomes sufficiently plastic to completely fill the mold cavity. Likewise the chilling temperature varies, but it should be noted that while with compression molding the die is actually cooled with water, in injection molding the temperature of the die is dependent, in the main, upon the piece being molded.

II GENERAL QUALITIES

DEVELOPMENT OF COMPOUND

When molding materials first came on the market, study was begun in Monsanto Plastics' laboratories to determine all the desirable qualities in a cellulose acetate molding compound, and how these qualities could best be brought together into a single material.

This study developed that cellulose acetate molding compound provides finished articles with a high degree of rigidity and toughness, low burning rate, high softening point; does not exude during intervals of injection and possesses just the right degree of fluidity or mobility to be easily molded.

However, this same study pointed out that there were certain characteristics which would have to be thoroughly understood and conquered before this plastic material would be suitable for widespread commercial molding. These characteristics were:

1. **Flow**
2. **Setting time**
3. **Welding property**
4. **Color stability and tone**
5. **Color combinations**
6. **Manufacturing duplication and continuity**

FLOW

Experience with the many molders using Monsanto Cellulose Acetate molding compound has shown that the flow characteristic of a material is the most important single factor in getting a good molded piece. To achieve the correct softness at the elevated temperature of molding and yet have the correct rigidity and toughness, was a difficult problem, but one which had to be solved.

In addition, it was necessary to understand the flow of the molten material entering the die, flowing along the runners, entering the complicated molding form and possibly being gated. This latter was not a problem that could be solved by fluid flow equations but one which had to be met by practical experiment and study.

The answer to flow problems lay in plasticizers, for it is a well-known fact that the more plasticizer used, the greater the plasticity and the greater the shock strength and elongation, but this involves a lower softening point and consequently lower molding temperature. Any lessening of the rigidity of the

finished piece had to be avoided, while lowering of the quantity of plasticizer meant possible burning of stock because of the elevated temperature which was necessary to give the stock sufficient fluidity to fill the mold.

Therefore, it was necessary to build up a tertiary system of plasticizers, correctly balanced to give high flow at the elevated temperature of molding, maintain the natural toughness of the cellulose base and finally lend it rigidity at room temperature.

Flow properties of molding compounds are controlled precisely by the ingenious Monsanto Plastics flowmeter, a device developed by Monsanto engineers. The flowmeter measures the viscosity of materials at tested temperatures, so the molder may know exactly how various compounds will flow at molding temperatures.

SET

With the molder operating in a highly competitive market, it is essential that he keep his production cycle to a minimum. To aid him, the injection machine manufacturer is continually increasing the speed of the injection, but essentially the main factor lies in the time taken for the molten plastic material to harden or set after it is in the die.

This time, as a rule, cannot be shortened by cooling the die severely, because by so doing the brilliant polish on the surface of the piece is lost.

Therefore, it was necessary that Monsanto Plastics develop a compound which would have a minimum temperature range between the distortion point and the plastic point.

The search for a material having the correct flow characteristics and ability to meet these temperature requirements resulted in a modifying plasticizer with a setting period which in actual practice has the astoundingly short period of *twelve seconds*.

A further method of increasing the speed of cycle is to increase the temperature. Although this sounds contradictory, the increase of temperature allows more shots per minute by always having the material plastic. Such treatment is possible with Monsanto Cellulose Acetate molding compound as it possesses a large range of thermal plasticity without being subject to local burning.

WELDING

Inserts, pins and circular pieces which break the plastic into two or more small streams, all introduced the problem of weld lines. The plastic stream would enter and set in layers, the outer surface of the stream "freezing" to the cold mold.

Naturally, the leading portion of the stream would cool as it flowed through a channel and retain only sufficient plasticity to be pushed along by the pressure of the stream behind it.

When two of these streams would meet at the far side of a doughnut-shaped piece, for example, the leading films of each stream were not sufficiently plastic to flow into each other. Thus they actually did not weld together and therefore had no strength. The result would be apparent on the surface of the finished piece as a line.

This problem likewise has been solved . . . the best evidence being the widespread use of Monsanto Cellulose Acetate molding compound in the optical field, where good welds are absolutely essential.

The method used in getting a satisfactory weld was to change the flow characteristic of the material from a *viscous* to a *turbulent* flow, thus preventing even a momentary formation of a hard semiplastic membrane on the leading edge of the stream of plastic.

COLOR STABILITY

Although Monsanto Plastics Division has many years of experience in the use of dyes and pigments in cellulose nitrate and acetate sheets, rods and tubes, it was found necessary to re-test all of these colors thoroughly in cellulose acetate molding com-

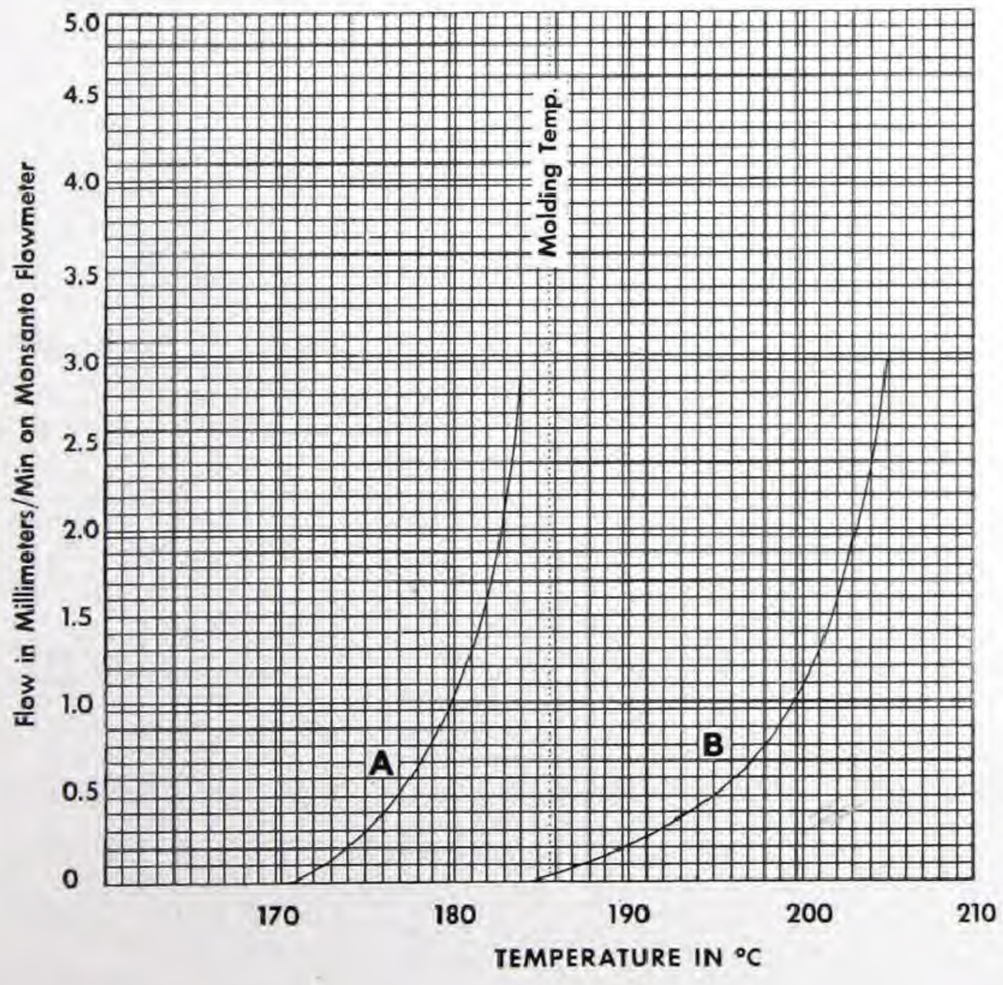
pounds since the high heat of the injection machine made some of these dyes and pigments fugitive.

To replace these fugitive colors, the dye manufacturers cooperated wholeheartedly and a new set of colors was developed and introduced. Today there are no problems on fugitive colors, since exhaustive tests show Monsanto's product will withstand more than 450° F. during injection and have a minimum life of 120 hours when subjected to actinic rays.

COLOR COMBINATIONS

In the early days of molding compound usage, only plain colors were required. However, it was not long before the interior decorator began to require accurate color matches for woodwork, or two and three color mottles to match the shades used in a room or in the article to which the molded piece was to be attached. These mottled pieces called for a new method of manufacture. The method developed by Monsanto can best be shown diagrammatically.

As shown in this diagram, a mottle would be formed, having B imbedded in A, the former retaining almost its original identity as a 5/16 or 3/16-inch piece. However, as B is softened to bring it to the left, it begins to become more and more of a streamer in the finished piece—finally losing its identity completely and fading into A. Although this system is fundamentally simple in mottles having several different colors each in a different configuration, difficulty of making an exact match increases. For this reason, though the molder as a rule mixes his own mottle, Monsanto specifies the amounts of each material and, as nearly as possible, the temperature at which it is to be molded.



PRODUCTION

In order to have material uniform throughout a batch and to duplicate the original material in each subsequent batch, great care has been taken in safeguarding every step in production of Monsanto Cellulose Acetate molding compound. It was found necessary, not only to produce a material which is completely colloided, but also a material in which the plasticizer had already become active in every phase into which it might possibly enter during the molding process.

The care in manufacture prevents any entrance of dirt, dust or other extraneous material during processing and eliminates any possibility of metal entering. However, to provide double assurance on the latter point, a large continuous magnetic separator has been installed.

Following this magnetic treatment, a magnetic shaking table removes all large pieces of the compound, giving the customer the size material which he has ordered and no oversize pieces which might not soften satisfactorily.

This brief outline of the production processes of Monsanto Plastics Division shows the care used to provide the molder with a material which will give complete satisfaction.

III PRINCIPLES OF MOLDING

A—INJECTION METHOD

Injection machines are not a new invention but are rather an adaptation to plastics of the older machines used in die casting of metals. However, familiarity with die casting, although an aid in handling molding compounds, does not assure success in handling them. Plastic molding involves a specialized technique of its own.

Preheating Compound

It has now become standard practice among molders to preheat the compound. This removes any danger from moisture absorption which may have occurred during very humid weather. Preheating is usually done in trays set in a drier. Temperatures in the drier are maintained at 70° to 80°C. depending on the time of heating and the efficiency of the drier. The heat used in preheating is not lost since Monsanto Cellulose Acetate molding compound is not a ready conductor, and thus retains temperatures while in the feed hopper and reduces the consumption of heat while in the heating chamber.

Introduction of Compound

The molding compound is fed to the heating chamber by means of a measuring device actuated by the injection ram. The material drops into the cylinder which is left free by the ram as it moves away from the heating chamber. On the return stroke the compound is pushed forward into the heating chamber. If an unusually large charge is desired, the compound can be packed into the cylinder by manual force; however, this procedure is not recommended, and as a rule will not be necessary. Amounts of material smaller than a full load can be controlled by a measuring cup.

The heating cylinder is designed to give efficient heat transfer to the compound by means of a torpedo-shaped insert, the material passing between the torpedo and the wall of the heating cylinder. A nozzle attached to the front of the heating cylinder compounds the material separated by the torpedo and conveys the plastic from the heating chamber to the mold through a gate and runners, the desired plasticity being maintained by the set temperature of the heating chamber.

This nozzle also serves another purpose—forward tapering to the small orifice outlet sets up a back pressure which causes the fresh compound in the heating chamber to be reduced to a plastic state and, in addition, prevents undue leakage.

With the chamber and nozzle filled, the plastic mass is forced into the die by the fresh charge from the hopper. This fresh charge is forced against the plastic mass by the injection ram, activated by a hydraulic pressure of from 800 to 1000 pounds. Each repetition of this injection process constitutes an injection cycle, the stroke of the ram filling the mold and replacing this molded material by fresh compound.

Introduction of Plastic to Mold Cavity

The nozzle, which joins against an elliptically shaped hole in the mold (especially machined so as to exactly fit the forward end) is in position to allow the plastic mass to be forced into the mold by the ram. The mold is designed with a tapered entrance or gate, leading from the orifice opening at the end of the nozzle to the center of the die, where it branches into one or more small paths called runners. These runners in turn lead into the mold cavities. The position and design of these runners are important, since they must allow speedy and uniform filling of the cavity and help hold the molded piece in place as the die opens so that the sprue may be withdrawn from the gate. ("Sprue" is the name given the solidified plastic material filling the tapered gate.)

Let us visualize the flow of plastic into the mold.

The ram forces the plastic through the nozzle into the gate, in the form of a continuous wave. Passing through the gate, the plastic enters the runners and flows into the cavity through a restricted opening. Frictional heat, due to the travel through the runners

and cavity entrance, helps to maintain the plastic in a softened condition. Obstructions in the mold, such as inserts and pins, will divide the wave and chill it slightly.

The divided wave will meet again, after surrounding the obstruction, to completely fill the cavity. Air in the cavity is forced ahead of the plastic wave and must escape by means of knockout pins, sleeves or specially placed vents. If the air is not allowed to escape, it becomes compressed and causes local burning of the stock because of the back pressure, due to heat of compression, and an incompletely filled cavity.

With the cavity filled, the ram maintains pressure sufficiently long to cause the sprue to set before withdrawing. The mold is kept closed long enough to allow the molded pieces to set sufficiently to be ejected without distortion.

Mold Temperature

All mold designers and builders provide for "ports" for circulation of warm or cold water through channels in the die. A very careful study of this cooling system is made by the die designers in order that cooling be equalized throughout the die, with no dead spaces or pockets where the water can become trapped and restrict free circulation. The wise molder will provide both hot and cold water inlets for the "ports," as better results are usually obtained by actually heating the die. For instance, it is sometimes possible to heat the side of the die, which gives the surface to the molded piece, and cool the inside portion. In this way, a brilliant polish and perfect surface will be given to the article without materially decreasing the speed of the cycle.

Ejection

The molded pieces are ejected from the mold by means of suitable knockout pins, sleeves or stripper plates incorporated in the mold design. These are mechanically operated in such a manner that they do not eject the molded piece until the die has opened sufficiently to remove the sprue from the gate.

The knockout pins will bend or badly distort the molded piece if it has not obtained sufficient rigidity at the time of ejection; however, they are so placed that even though they leave a small mark, it is not apparent to the ultimate consumer. Or, if desired, such marks can be easily buffed from the surface. Naturally, the knockout pins must exert their force only on the heavy sections of the molded piece.

Handling Molded Pieces

Following ejection of the molded piece from the die, there are several ways in which it may be handled. Almost every molder uses his own method of handling so as to best suit the needs of his plant. In large plants, for instance, a continuous belt runs behind the machine and the pieces fall on it and are delivered to a fabricating department. In smaller plants, the operator utilizes his time between mold ejections by placing the still semiplastic piece on a table where it is cooled and later broken from the runners. Some molders prefer to drop the hot pieces into water so as to hasten the setting of the pieces; however, due caution should be taken to limit immersion because of possibility of warpage and loss of rigidity.

Utilizing Scrap

As mentioned in the introduction, Monsanto Cellulose Acetate molding compound is thermoplastic and all excess material can be reclaimed and re-used in future molding cycles. This is entirely practicable; but to maintain set temperatures, pressures and cycles, it is preferable to mix the reground scrap with new material of the same type as that from which the scrap was obtained, or even with slightly softer material.

To regrind the runners, sprues, vents, etc. entails very little additional expense as there are several excellent grinding machines on the market, any one of which will regrind all the scrap from 7 to 10 injection machines. In some cases there is a loss of from 2 to 3 pounds per day by leakage from the nozzle. This material should not be re-used since grease and dirt become incorporated with this stock and render it useless.

B—COMPRESSION METHOD

Compression molding is that type of molding where the plastic is placed in a heated mold, either as granules or a blank, and is softened by the heat of the

mold. This mold is built in two pieces—a top and a bottom—which come together under pressure, compressing the plastic and melting it so that the cavity or cavities become filled. The mold is then chilled before opening to remove the molded piece.

Compression molds are used in hydraulic or mechanical presses. Usually the two sections of the mold are fastened to the platens of the press. The molds are cored so that steam or cold water may be passed through the channels in their interiors, to afford a means of heating and cooling.

Loading

The mold cavities are filled with the proper amount of material, usually while the mold is being heated. Filling the mold cavities is usually accomplished by means of a loading form which has reservoirs containing sufficient material to fill the cavities. A dump mechanism allows the granules or blanks to fall into place when the form has been put in position above the top of the cavities.

Molding Temperature

Once the compression mold is loaded and brought up to the required temperature, it can be closed slowly—usually by means of 250 to 300 lbs. hydraulic pressure. When within .025 to .050 inch of being closed, the high pressure—2500 lbs. per sq. in.—may be applied and cooling started. The exact time of heating, the temperature, the time on low pressure, time on high pressure and time for cooling will vary with different molds. Therefore, compression molding to a large part requires a series of trials to find the best operating condition for the particular job on hand. Monsanto Plastics Division is in a position to assist the molder in selecting the right type of granules or blanks for the job and to aid in finding the correct operating cycle.

Owing to the length of compression cycles, it is a common practice to have one operator run more than one press at a time. However, it is apparent that such technique as is used in phenolic molding, where as many as six or seven presses are attended by one operator, is not usually possible with molding compound because of the short cycle which can be obtained under correct conditions.

In production of molds for compression work, the experience of the many designers of such molds may be relied on. However, it is well to point out very briefly some of the important factors to be considered in mold design.

Undercuts

Although adding to the cost, and possibly increasing wear in a die, undercutting is good practice and often materially aids in the ready removal of the molded piece, particularly in the tilting head or split-mold type press.

In semiautomatic presses where ejector pins are used to mechanically eject the molded piece, there are two main causes of trouble to be avoided.

The first of these is that the material may tend to stick to that portion of the die not having the pins. To avoid this problem, the portion of the die having knockout pins should be kept somewhat warmer than the other half of the die. Another solution to the problem is to roughen the "lands" between cavities on the portion of the die having pins and smoothing the "lands" on the other portion.

The second cause of trouble is found when the knockout pins penetrate into the molded pieces, causing them to stick to the pin. The only action to be taken in such a case is to cool the molding further.

Flash Allowances

In the simple overflow type mold, the entire study of design must be based on correct flash allowance. It becomes immediately apparent that incorrect design or the allowing of poor fits at any point of the mold may cause eventual breaking or cracking of the die.

Ejector Pins

Ejector pins are placed in compression molds to assist in removing molded pieces. Some ejectors are operated by hand. Others are arranged to function when the press opens, by means of stops or lifts fastened to the ejector plate, and actuated either by lowering or raising the press. Close fits on ejector pins are essential because the soft condition of the plastic during compression molding may easily cause the material to flash around the pin so that it binds when cool, resulting in damage to the mold if not opened gently.

IV MONSANTO CELLULOSE ACETATE MOLDED SHEETS

Molded sheets or slabs are supplied by Monsanto Plastics Division in thicknesses of .150″ to 1.0″ and in any size up to 21″ wide and 50″ long. In these molded sheets are utilized the same formulations as in molding compounds of both injection and compression types. All colors supplied in injection type can be duplicated in molded sheets.

Molded sheets are generally used in making blanks for compression molding. This method is used extensively by those molders who operate hand presses.

With this material, a single cavity mold can be operated remarkably fast. The method usually employs a heated mold in which a blank, previously softened on a steam or hot plate, is placed. Pressure is applied by lever action. The mold then is opened and the formed piece removed and allowed to cool. The same principle can apply to a multiple cavity mold and press, mechanically operated.

V FORMULAE AND COLOR DESIGNATIONS

In order to make a readily understandable and simple nomenclature for Monsanto Cellulose Acetate molding compound formulae, the following system of symbols has been devised:

VH—Very Hard
H—Hard
MH—Medium Hard
M—Medium
MS—Medium Soft
S—Soft
VS—Very Soft

Between each group, ten divisions are made so that the intermediate formulae can be graduated. For example, there is an MSI, an MS2, an MS3, etc. The position of each numeral has been worked out by a mathematical compilation of the active plasticizer content, which progressively becomes softer as the numbers increase. Useful data on some of the properties of these divisions is shown in the table on the following page.

It has also been found advisable to set up another system for the colors and color combinations. This is given in the table which follows. These numbers are assigned only to colors which are approved by an individual customer for a specific purpose. When a request is received from a customer to match a color, the sample is given an "M" number. When, however, this color is approved by the customer and the material is made in larger scale production, the permanent color number is given to it as well as the correct formula designation. The customer will be informed of this change when it is made so that no misunderstanding will arise.

	Opaque	Transl.	Transp.	Mottles
White (cream) commencing with	1	1001	2001	3001
Red (orange, salmon, coral, cerise, pink) commencing with	101	1101	2101	3101
Yellow (ivory, buff) commencing with	201	1201	2201	3201
Green commencing with	301	1301	2301	3301
Blue commencing with	401	1401	2401	3401
Lavender (purple, orchid) commencing with	501	1501	2501	3501
Brown (tan) commencing with	601	1601	2601	3601
Grey (olive) commencing with	701	1701	2701	3701
Black commencing with	801			

Water-clear Transparent or Crystal will run from 2001 to 2099. Shell colors will run from 3901 to 3999. Pearl colors will commence with 4001. The prefix letter F will be used in front of some numbers to indicate Monsanto Cellulose Acetate slab stock and the prefix letter G will be used in front of others to indicate granulations.

VI FORMULAE AND THEIR USES

	VH	MH	M	MS	S	VS	H
USE	This type formula is used exclusively for mottle work	Novelties Heat resistant pieces	Novelties Optical General	Thick objects General	For relatively thin objects where weld and strength are important—i. e., boxes, etc.	For thin wall castings—ferrules where good strength is desired—Good weld, high gloss	For slab and special uses
Machine	Dependent upon other stock used in making mottle	1. Lester 2. HPM 3. Leominster Tool 4. Reed-Prentice	Same as MH formulae	1. Lester 2. HPM 3. Leominster Tool 4. Reed-Prentice 5. Isoma 6. de Mattia 7. Baldwin-Southwark	All types of machines	All types of machines	Compression
TEMP. FOR MOLD	380-410° F.	380-410° F.	360-400° F.	340-380° F.	320-360° F.	300-340° F.	300-340° F.
Impact Strength	60-100 5″x½x½ Charpy Impact	over 100	.....	.....	.....	Maximum	Maximum
Distortion Temp.	75° C.	65-70° C.	50-65° C.	40-50° C.	45° C.	40° C.	70° C.
*Flow in mm per min. at 180° C.	.25	.35-.55	.45-.65	1.-2	2-3	3-5	.40-.70
Mold Shrinkage	.....	.002-.003	.002-.003	.003	.003	.002	.005/in
Water absorption 48 hrs. at 20° C.	1-2%	2.7-1%	1.60-2.90%	2.60%	2.60%	2.60%	1.4%
Wt. loss at 100° C. for 48 hrs.	.1-.5%	.5%	.5%	.6%	.7%	.7-.8%	.5%

*This flow is obtained on the Monsanto thermoplastic Flowmeter, a machine especially designed by Monsanto Plastics Division for research in thermoplastic materials.

VII GENERAL PROPERTIES

It is not possible to give a complete table of properties of Monsanto Cellulose Acetate molding compound, for properties will naturally vary from formula to formula. However, in the next table are listed most of the essential properties, giving ranges that embrace nearly all standard formulae. If further specific data is required, your inquiry will bring complete details.

MECHANICAL PROPERTIES

Specific Gravity	1.27-1.63
Specific Volume, cubic inches per pound	21.8-17.0
Weight per Cubic Inch (based on sp. gr. 1.3)	.047 lb.
Refractive Index N_D	1.47-1.5
Compressive Strength, lbs/sq. in.	11,000-16,000
Tensile Strength, lbs/sq. in.	4,000-5,000
Elongation	10-48%
Flexural Strength, lbs/sq. in.	5,200-8,800
Impact Strength, Inch Pounds, Charpy notched specimen, per sq. in.	3-12
Modulus of Elasticity, lbs. per sq. in. x 10^5	2-4
Impact Strength, Inch Pounds, Charpy A. S. T. M. No. 4 unnotched specimen	Over 100
Brinell Hardness (10 kg.load)	6-7.5
Scratch Resistance, Bierbaum Micro-character	5.4-12

MOLDING PROPERTIES

Type	Thermoplastic
Molding Qualities	Excellent
Compression Molding Temperature	250-350° F.
Compression Molding Pressure, lbs/sq. in.	500-5,000
Injection Molding Temperature	300-500° F.
Injection Molding Pressure, lbs/sq. in.	3,000-30,000
Compression Ratio	2-2.8
Tendency to Cold Flow, Room Temperature	None to Very Slight
Mold Shrinkage (Cold Mold to Cold Piece):	
Injection	.002-.003″/inch
Semi-positive	.005-.007″/inch
Flash	.008-.009″/inch
Extruding Qualities	Excellent
Molding Methods Applicable	Lends itself readily to all forms of dry hot molding.

THERMAL PROPERTIES

Burning Rate, .060″ thickness	1.5-2.0″/minute Slow Burning. Approved by Underwriters' Laboratory.
Thermal Conductivity, 10^{-4} calories per second per sq. cm./1°C. per cm.	5.4-8.7
Flash Point, °C.	530-540
Specific Heat, calories/1°C./gram	0.3-0.45
Thermal Expansion, 10^{-5}/F.	8-9
10^{-5}/C.	14-16
Resistance to Heat, °F. (continuous)	140-180
Distortion Under Heat, °F.	122-155
Softening Point, °F.	140-175

ELECTRICAL PROPERTIES

Volume Resistivity ohms/cms. (50% R. H.)	(4.2-6.2) x 10^{12}
Breakdown Voltage, 60 cycles, volts/mil (instantaneous)	800-850
Dielectric Constant, 60 cycles	5.8-6.0
10^6 cycles	4.4-4.7
Power Factor, 60 cycles	.042-.058
10^6 cycles	.038-.042

CHEMICAL PROPERTIES—PHYSICAL PROPERTIES

Odor	None
Taste	None
Effect of Age	Slight Hardening
Effect of Sunlight	Practically None. Fades Some Colors.
Effect of Ultraviolet Light	Slight. Fades Some Colors.
Effect on Metal Inserts	None
Light Transmission. .060″ gauge, colorless	85-92%
Effect of Weak Mineral Acids	Slight
Effect of Strong Acids	Decomposes
Effect of Weak Alkalis	Slight on Short Exposure
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hrs. immersion, ASTM method	1.4-2.0%
Moisture Transfer, .020″ gauge, grams/square meter/day	35-150
Solubility: Soluble in	Low molecular weight esters Ketones Hydroxy esters Tetrachlorethane Ethylene dichloride alcohol mixtures
Softens in	Alcohol Esters
Swells in	Chlorinated Hydrocarbons
Insoluble in	Aromatic Hydrocarbons Aliphatic Hydrocarbons Animal Oils Mineral Oils Vegetable Oils Ethers

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as many mottles, pearl and ornamental configurations.

Form: Powder and Molded Slabs

VIII HOW TO ORDER

When ordering Monsanto Cellulose Acetate molding compound or requesting samples, it is advisable to furnish ample information so that the most appropriate material for your purpose may be supplied.

The following information is desirable to avoid errors and consequent disappointment:

Color: A simple designation of color may be sufficient, but if practicable, always supply a sample to be matched. If this is not possible, request Monsanto Cellulose Acetate molding compound samples from which the exact color and degree of translucence may be selected. When mixtures or mottles are wanted, please describe them as accurately as possible. For example—"Blue white variegation, white predominating, occasional deep blue striations." Monsanto Cellulose Acetate colors are numbered when supplied; please use the number when re-ordering to insure an exact match.

Flow: For most applications, medium-soft flow degree is best. It will be furnished unless a different flow is specified. If experimentation has suggested the advisability of a different flow, be sure to specify it on the order.

Form: The coarseness, or fineness, of the granulation of Monsanto Cellulose Acetate molding compound is determined by the mesh of the screen through which it will pass. Available standard sizes run from 3/16″ to 5/16″. Unless otherwise specified, 3/16″ will be furnished.

Application: Particularly on initial orders it is advisable to briefly describe the product to be molded and whether the injection or compression molding process is to be used.

Machine: It is always best to specify what make of machine is to be used, for it has been found that there can be as much variation from machine to machine as between die to die. This does not mean that any machine is preferable to another for use with Monsanto Plastics, but rather that each varies from the other in the speed of injection, length and type of heating chamber, and other factors.

Inserts: Pins and inserts generally present their individual problems and if it is possible to describe how these are placed, spaced or used, it will simplify the selection of proper material.

Welding: If exceptional welding problems exist these should be explained, since standard materials might not be satisfactory in such special cases. An explanation of the problem will bring you the best compound to meet it and still provide satisfactory results.

IX HOW TO STORE

Monsanto Cellulose Acetate molding compound is packed in bags and shipped in fibre boxes. The hazard of dust and dirt in the storing and handling of molding material is always a serious one, especially when pure colors, or transparent or translucent effects are to be obtained in finished products. For this reason, the utmost precautions should be taken at all times. Always keep Monsanto Cellulose Acetate molding compound in a clean, dry place. All containers should be kept tightly covered.

Uncompounded cellulose acetate flake absorbs from 5 to 8% moisture from an atmosphere of 80% relative humidity. While this tendency is much reduced in Monsanto Cellulose Acetate molding compound, there may be a slight moisture absorption from very humid atmospheres. For greater accuracy in molding, therefore, storage in dry atmosphere and in closed containers is essential for best results.

The ordinary precautions against combustion are quite adequate in storing. The report of the Underwriters' Laboratories reads: "Hazards of this product in use are judged to be small and in storage somewhat less than would be presented by common newsprint paper in the same form and quantity."

X APPLICATIONS

The development of injection molding has broadened rapidly the already wide field of thermoplastics. It is today difficult to name a single industry in which plastics are not coming into increasing use due to their inherent characteristics and the ease of fabrication by modern molding methods. Finished products, manufactured from Monsanto Cellulose Acetate molding compound are today found in widely varied fields, of which the following are typical examples:

AUTOMOTIVE

Dome Lights
Electrical Equipment
Gasoline Caps
Gear Shift Balls
Hardware
Instrument Panels
Window Moldings
Tail Lamps

SPORTING

Lawn Bowl Markers
Fishing Reels
Golf Tees

ELECTRICAL

Commutator Parts
Hearing Devices
Light Switches
Outlet Plugs
Switch Plates
Vibrator Combs

AIRPLANE

Hardware
Instrument Panels
Control Buttons

INDUSTRIAL

Adding Machine Keys
Motion Picture Film Cores
Miners' Lamp Housings
Oil Cups
Oil Gauges
Protective Goggles
Valve Handles
Yarn Spool Ends

HANDLES

Safety Razors
Whisk Brooms
Tools
Cutlery
Kitchen Utensils

COSMETICS

Containers
Compacts
Lipstick Holders
Jar Tops

HARDWARE

Door Knobs
Escutcheon Plates

RADIO

Dials
Cabinets
Panels
Knobs

PERSONAL

Bracelets
Buckles
Buttons
Combs
Costume Jewelry
Goggles
Hair Ornaments
Pencils
Pens
Spectacle Frames

UMBRELLA

Handles
Ferrules
Tips

XI APPENDIX

MONSANTO POLYSTYRENE MOLDING COMPOUND

Monsanto's newly developed polystyrene molding compound has entered the injection and compression molding field, not as a competitor to cellulose acetate molding compound, but rather as a material to open still added fields to molding endeavor. Where lack of alcohol resistance or interference at radio wave frequencies has been a problem previously, this new Monsanto Polystyrene has special advantages. Another advantage of polystyrene is to be found in those applications where molded pieces are subjected to extreme humidity and relatively high temperatures for long periods.

The previous description of molding machines and molding processes applies equally well to any molding compounds supplied by Monsanto—both Monsanto Cellulose Acetate and Monsanto Polystyrene.

As with Monsanto Cellulose Acetate molding compound, Monsanto Polystyrene has been withheld from the market for exhaustive study of its properties and applications. This research, now completed, enables Monsanto to provide real assistance to the molder in his handling of this important new resin.

Monsanto Polystyrene, contrasted with Monsanto Cellulose Acetate molding compound, is a synthetic resin of the Vinyl family. This new resin has many remarkable qualities, most startling of which are its resistance to alcohol, low interference at radio wave

frequencies, low water absorption and transfer, clarity, rigidity and a wide range of molding temperatures.

The clarity of the material means new possibilities in the optical field, as one example of application. In addition, this clarity allows the material to be produced in a wide range of color tones, as varied as the imagination of the color expert producing them.

Its low interference at radio wave frequencies gives Monsanto Polystyrene an entrance into fields that have, as yet, been little developed by molding compounds. To the airplane manufacturer, it means a cowling for the radio beacon antenna which, in addition, streamlines the plane. To the radio manufacturer, a unique use of plastics in radio tubes, grilles and other parts.

The fact that Monsanto Polystyrene can be molded over a tremendous range of temperatures (from 320° to 450° F.) gives it a marked advantage. However, it is well to remember that injection molding under 370° F. is not advisable, since below this temperature the material is not made sufficiently plastic and an unmolding effect in the form of "crazing" on the surface may appear.

Two standard formulae of Monsanto Polystyrene molding compound already are in production. This is not a limitation as it would be with cellulose acetate as these two formulae, as explained previously, mold over a very long range of temperatures and have a very short set, so that the cycle can frequently be cut off below fifteen seconds. One of these formulae is Monsanto Polystyrene in practically a nascent form; the other contains a lubricant plasticizer which aids in the molding of Monsanto Polystyrene in very complicated dies. If the customer has a special application which neither formula appears to fit, and it is practical to use this resin for such an application, Monsanto Plastics Division will make a polystyrene material to fit his needs.

Experience with many molders has taught that when thick molded pieces of polystyrene are exposed to actinic rays for long periods of time, a slight yellowing discoloration is apparent which might cause the eventual rejection of the pieces. With thin pieces, this yellowing is so much less noticeable that it probably would not be apparent under even close examination. Experience also has shown that when the molded piece is subjected to heavy or continual flexure an unmolding tendency will become apparent in the form of a slight craze. These facts are presented frankly, in the belief that the advantages of Monsanto Polystyrene for many uses are so great they outweigh these minor inherent disadvantages, which after all apply in only exceptional instances.

Many consumers may feel the price of polystyrene is too high to meet cellulose acetate on a competitive market. However, if the molder will weigh a complete assembly of polystyrene against a complete assembly of cellulose acetate he will find that the polystyrene weighs approximately 17.7% less. This means that 17.7% should be subtracted from the original cost, thus making the actual cost of crystal polystyrene less than that of crystal cellulose acetate—and colored polystyrene very little more than colored cellulose acetate. Both materials — polystyrene and cellulose acetate — have great advantages in their individual fields. Both have a place in the future progress of plastics.

The following is a short list giving the properties of Monsanto Polystyrene which may be of importance to the molder:

Molding Quality	**Good**
Compression Molding Temperature	**280-325° F.**
Compression Molding Pressure	**300-3,000 lbs. per sq. in.**
Injection Molding Temperature	**350-450° F.**
Injection Molding Pressure	**1,000-30,000 lbs. per sq. in.**
Compression Ratio	**2.5**
Mold Shrinkage, inches per in.	**0.002-0.0025**
Specific Gravity	**1.05-1.07**
Specific Volume, cu. in. per lb.	**25.9-27.8**
Burning Rate	**Slow**
Effect of Age	**None**
Effect of Sunlight	**Yellows**
Effect of Weak Acids	**None**
Effect of Strong Acids	**None**
Effect of Weak Alkalis	**Crazes**
Effect of Strong Alkalis	**Crazes**
Effect of Organic Solvents	**Widely Soluble**
Color Possibilities	**Unlimited**
Light Transmission	**More than 90%**

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MONSANTO
CELLULOSE ACETATE

SHEETS • RODS • TUBES
CONTINUOUS LENGTHS

DATA GUIDE

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

TECHNICAL DATA

MONSANTO CELLULOSE ACETATE is a thermoplastic material supplied in sheets, continuous lengths, rods, tubes and molding compounds.

This plastic is especially distinguished for its exceptional resistance to actinic light rays (sunlight) and its flame-resistant properties.

Duplicates the Spectrum

Monsanto Cellulose Acetate is made in an infinite range of colors, from clear crystal and pure white on the one extreme to jet black at the opposite extreme; in solid colors and in thousands of combinations of mottled, grained and veined effects. It is produced in transparents, translucents or opaques. One unusual effect is attained by producing Monsanto Cellulose Acetate in a perfect imitation of iridescent pearl.

Starts with "Linters"

The cotton which provides the cellulose base for Monsanto Cellulose Acetate is called "linters," and is the short fibre cotton not suitable for spinning.

The cotton linters are purified and bleached, washed, dried, fluffed and then compressed into bales. These linters then are acetylated: that is, treated with acetic acid and acetic anhydride in the presence of a catalyst.

This process transforms the cotton into cellulose acetate, which must then be purified to free it of excess acid. The acetylating process is extremely exacting both as to the equipment and ingredients used.

Production is Scientifically Accurate

The purified cellulose acetate is then ready for incorporating into a Monsanto Plastic. It is mixed with plasticizers or softeners, which impart flexibility to the resulting plastic. At this point, solvents also are added, to reduce the mass to a dough-like consistency.

After mixing, the plastic mass is kneaded on large chromium plated rolls, which remove the solvent and make the material compact and homogeneous.

How Sheets are Produced

After this mass is baked into a large cake, sheets are veneered from it. Monsanto standard sheet size is 20″ x 50″, thus containing an area of one thousand square inches per sheet. This makes it very easy to compute the value of any size piece cut from the sheet. Sheets are in gauges from .003″ in steps of .0025″ up to .020″, and from then on to any specified thickness up to ¾″ (or even thicker when specified).

Laminated Sheets

For some types of work, sheets are laminated together so that if the more expensive pearl effect is needed for some particular work, the pearl sheet can be made very thin and laminated to a lower priced sheet to produce the desired rigidity and thickness. This lamination may consist of almost any number of sheets in contrasting color to produce a striped edge.

Continuous Process

Monsanto Plastics Division has developed a continuous process for producing cellulose acetate in standard weights, commercial widths and any length—the material emerging in giant rolls like newsprint paper. This eliminates the waste sometimes resulting from use of standard sheet stock, where the size of the material required is less than the sheet size.

How Rods are Made

Rods are made by two methods—extruded or cut. The extruded rod is usually used for solid colors or for certain graining effects, where the graining can be parallel to the rod. Cut rods are made when block type mottles are desired in color or pattern effects that cannot be accomplished by extruding.

Cut rods are made from a block of the material by much the same veneering process that sheets are cut from a block.

Rods, either extruded or cut, are supplied as they come from the extruder or from the cutting machine, or they can be centerless ground to exact specifications if the work in hand requires that treatment.

Producing Tubes

Tubes are made by three principal methods—extrusion, spiral wound or butt weld. The extruded tubing is mostly used for solid colors, or for colors with graining effects where the grain. may run parallel to the tube. This tubing can be supplied either as it comes from the extruding machine, or it can be supplied stretched and ground to exact specifications for size, both on inside diameter and outside diameter.

Spiral wound tubing, as its name implies, is made from sheet material, spiral wound and welded by a solvent under pressure. This type of tubing is used where color effects are desired that cannot be produced by the extrusion method.

Butt weld tubing is made from sheets, folded and welded with a solvent under pressure. For all practical purposes both the spiral wound and the butt weld tubes can be considered seamless. The action of the solvent used to make the joint unites them, giving them the full strength of the sheet itself.

Rods and tubes supplied by the extrusion method have a standard length of 50″, but can be supplied in other lengths when specified. Spiral wound and butt weld tubing are generally made in 30″ and 36″ lengths, but also can be supplied, on special specification, in other lengths.

Fabrication Methods

Monsanto Cellulose Acetate is fabricated by cutting, sawing, punching, drilling, drawing, molding, turning, printing, embossing and polishing. Being a thermoplastic material, Monsanto Cellulose Acetate is softened by the application of heat. It then can be drawn into an infinite variety of cup-shaped or dome-shaped items, and can be bent into desired form, as in the manufacture of transparent boxes.

These operations merely involve heating the material to a specified temperature, and placing it in a die to draw or bend, as the case may be, and chilling it while in the die under pressure.

Likewise, Monsanto Cellulose Acetate can be molded, in which case pellets of the desired size are laid in a hot die or preheated, and pressed into the desired shape under pressure of approximately 3,000 pounds per square inch of projected area of molding surface.

In this case the dies consist of upper and lower halves in which the proper cavities are provided. Outstanding and very familiar examples of this technique are typewriter keys, adding machine buttons and dentures as molded by the dental profession.

For Printing Requirements

For printing, which is a specialized industry, Monsanto Cellulose Acetate sheets are supplied in a mat finish. Printing is done with special formula inks and the printed sheet is later press polished, which makes the printing permanent and provides a smooth and glossy surface.

This operation consists of placing the printed sheets between highly polished plates, and pressing them under heat, and allowing them to chill while under pressure. By this means the polished surface of the plate is reproduced on the plastic sheet.

Monsanto Cellulose Acetate can be cemented, as in the case of certain built-up boxes, and spiral and butt weld tubing by the use of a Monsanto solvent which firmly unites the surfaces to be cemented.

Additional Fabrication Notes

Tool marks on finished fabricated products are readily polished off. The ordinary method of polishing is to use a muslin wheel with a mixture of pumice and water. The piece is then given a high lustre by subsequent operations on other wheels using rouge. Another method is to tumble-polish, and by this method certain types of products, which lend themselves to this technique, can be given a satisfactory finish. In some cases, tumble-polished pieces are given a final hand polish on a wheel, which, of course, produces a much higher gloss.

Since Monsanto Cellulose Acetate is used in an extremely wide range of applications, it is produced in many formulations, in each of which is used special ingredients which impart certain properties to meet specific requirements. In other words, it might well be termed a "custom-built" plastic designed to meet the varying needs of industry.

PROPERTIES OF MONSANTO CELLULOSE ACETATE

MECHANICAL

Specific Gravity	1.27-1.60
Specific Volume, cubic inches per pound	21.8-17.4
Density, grams/c.c.	1.22-1.62
Weight per Cubic Inch	20.8-26.2 grams
(based on specific gravity)	.046-.058 pound
Refractive Index N_D	1.48-1.51
Tensile Strength, lbs/sq. in.	6,000-8,000
Elongation, per cent	10-50
Bursting Strength (Rupture) lbs/sq. in.	350-450
Modulus of Elasticity, lbs/sq. in. x 105	1-3
Impact Strength, Charpy (notched) per inch square	2-7
Brinell Hardness, 10 kg. load	6-11
Machining Qualities	Very Good
Shrinkage	0.2-2.0%

MOLDING PROPERTIES

Type	Thermoplastic
Molding Qualities	Excellent
Compression Molding Temperature	180-240° F.
Compression Molding Pressure lbs/sq. in.	100-500
Preforming	Very Good
Tendency to Cold Flow	Very Slight
Molding Methods Applicable	Extrusion, Swaging, Shearing—All Good
Mold Shrinkage, inches per inch:	
Positive	.002-.003″
Semi-positive	.005-.007″
Flash	.008-.009″
Extruding Quality	Excellent

THERMAL PROPERTIES

Burning Rate	1.5-2.0″/minute (.060″) Slow Burning—Approved by Underwriters' Laboratories
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	5.4-8.7
Flash Point, °C.	530-540
°F.	986-1,004
Specific Heat, calories/1°C./gram	0.3-0.4
Thermal Expansion, 10^{-5}/°C.	5-16
Resistance to Heat, °F. (continuous)	140-180
Softening Point, °C.	82-190
°F.	179-374
Effect of Heat, Dry	Little or None
Moist	Slight Swelling
Heat Distortion, °C.	50-100
°F.	122-212

ELECTRICAL PROPERTIES

Volume Resistivity, ohms/cms (50% R. H.) 30° C.	(5-30) x 10^{12}
Breakdown Voltage, 60 cycles, volts/mil	600-1,800
Dielectric Constant 25° C.,	
60 cycles	1.12-3.9
10^6 cycles	4.2-5.3
Power Factor, 25° C.,	
60 cycles	0.44-1.1%
10^6 cycles	.038-.091

CHEMICAL PROPERTIES — PHYSICAL PROPERTIES

Odor	None, to Mild Aromatic
Taste	None
Effect of Age	Slight Shrinkage
Effect of Sunlight	Practically None—Some Colors Fade
Effect of Ultraviolet Light	Very Slight—Some Colors Fade
Effect on Metal Inserts	None
Light Transmission, .060″ colorless	91.1%
Effect of Weak Mineral Acids	Fair Resistance
Effect of Strong Acids	Decomposes
Effect of Weak Alkalies	Slight
Effect of Strong Alkalies	Decomposes
Water Absorption 25° C. (Maximum)	3.5-5.0%
Effect of Hot Water	Softens and Swells
Effect of Cold Water	None
Moisture Transfer, gms/sq. meter/day/.005″	35-150

Solubility: Soluble in—

Low Molecular Weight Esters	Ketones Hydroxy esters Tetrachlorethane Ethylene Dichloride-alcohol mixtures
Softens in—	Alcohols Esters
Swells in—	Chlorinated Hydrocarbons
Insoluble in—	Aromatic Hydrocarbons Aliphatic Hydrocarbons Animal Oils Mineral Oils Vegetable Oils Ethers

Color: Available in an extremely wide variety of transparent crystal, translucent, pastel and opaque colors, as well as in many mottles, pearls and ornamental configurations.

Forms: Sheets, rods, tubes and molding compounds.

PRINTED IN U. S. A.

MONSANTO PLASTICS

PRODUCTS OF MONSANTO CHEMICAL COMPANY
PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

MONSANTO
CELLULOSE NITRATE

SHEETS • RODS • TUBES

D A T A

G U I D E

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

TECHNICAL DATA

MONSANTO CELLULOSE NITRATE is a cellulose nitrate-camphor composition of the thermoplastic type, supplied in sheets, rods and tubes.

It is difficult to realize, when examining this clear, lustrous material, that it is primarily a vegetable product, originating from cotton.

To produce Monsanto Cellulose Nitrate, however, the cotton passes through a lengthy and involved process, scientifically controlled at every point.

From "Linters" to Cellulose Nitrate

The cotton used in this plastic is called "linters" and is the short fibers not suitable for spinning. The cotton linters are highly purified, washed, dried, fluffed and compressed into bales. These linters then are treated with a mixture of nitric and sulphuric acids and water under laboratory controlled conditions.

When so treated, the cotton is called cellulose nitrate or nitrocellulose. After a further thorough purification process, which insures latent stability in the final plastic, the refined cellulose nitrate is mixed with camphor and alcohol to form the colloidal plastic structure.

Molded into Huge Cakes

Large chromium-plated rolls are then used to knead the plastic, removing much of the alcohol and compacting and homogenizing the texture of the material. By skillful manipulation, the mass is built up into slabs about 1″ thick and about 20″ x 50″ in size. A number of these slabs are laid on top of a steel plate and molded in huge baking presses under heat and pressure. This produces a solid cake from which later are produced sheets, rods and tubes.

A Pioneer Plastic

Monsanto Cellulose Nitrate is one of the oldest of the plastics. It is made in an infinite range of colors from clear crystal and pure white on the one extreme to jet black at the opposite extreme; in solid colors, and in thousands of combinations of mottled, grained and veined effects.

This plastic is supplied in transparents, translucents or opaques. It is also made in a perfect imitation of iridescent pearl, which effect is created as a solid overall, in many kinds of mottles and in an infinite variety of colors.

Sheets are sliced from a large cake of the plastic. Monsanto standard size is 20″ x 50″, thus containing an area of one thousand square inches per sheet which makes it very easy to compute the value of any size piece cut from the sheet. Standard sheets are in gauges from .003″ up to .030″, and from then on to any specified thickness up to ¾″. (Even thicker pieces can be supplied on special demand.)

Lamination May Save Costs

For some types of work, sheets are laminated so that if the more expensive pearl effect is needed, the pearl sheet can be made very thin and lam nated to a lower priced sheet to produce the desired rigidity and thickness. In some instances, to produce an effect on the edge, this lamination may consist of almost any number of sheets in contrasting color to produce a striped surface.

How Rods are Made

Rods are made by two methods, extruded or cut. The extruded rod is usually used for solid colors or for certain graining effects, where the graining can be parallel to the rod.

Cut rods are made when block type mottles are desired in color or pattern effects that cannot be accomplished by extruding. Cut rods are made from a cake through much the same veneering process by which sheets are cut from a cake.

Rods are supplied as they come from the extruder or from the cutting machine, or they can be centerless ground to exact specifications if the use requires that treatment.

Methods of Tube Manufacture

Tubes are made by three principal methods—extrusion, spiral wound or butt weld. The extruded tubing is mostly used for solid colors, or for colors with graining effects where the grain may run parallel to the tube. This tubing can be supplied as it comes from the extruding machine, or it can be supplied stretched and ground to exact specifica-

tions for size, both on inside diameter and outside diameter.

Spiral wound tubing, as its name implies, is made from sheet material, spiral wound and welded by a solvent under pressure. This type of tubing is used where color effects are desired that cannot be produced by the extrusion method.

Likewise butt weld tubing is made from sheets, folded and welded with a solvent under pressure. For all practical purposes both spiral wound and butt weld tubes can be considered seamless as the action of the solvent welds the joints to the full strength of the sheet itself.

Rods and tubes supplied by the extrusion method have a standard length of 60″, but can be supplied in other lengths. Spiral wound and butt weld tubing is generally made in 30″ and 36″ lengths, but also can be supplied, on special specification in other lengths.

Adaptable in Fabrication

Monsanto Cellulose Nitrate is fabricated by cutting, sawing, punching, drilling, drawing, molding, turning, printing, embossing and polishing. In addition, it can be plasticized by immersion in a solution and stretched over other materials to provide whatever finish the manufacturer may desire. One such use is the application of this material over wooden heels on women's shoes. It is also used to cover toilet seats, clothes hampers, certain types of furniture and boxes.

Being a thermoplastic material, softened by the application of heat, Monsanto Cellulose Nitrate can be drawn into an infinite variety of cup and dome shapes, and can be bent into desired form. These operations merely involve heating the material to the desired specified temperature, placing it in a die to draw or bend, as the case may be, and chilling it while in the die under pressure.

Molding Cellulose Nitrate

This material can be molded, in which case pellets of the proper size are laid in a hot die or preheated, and squeezed into the desired shape under pressure of approximately 3,000 pounds per square inch of projected area of molding surface. The dies consist of upper and lower halves in which the proper cavities are provided, and the pellets are placed in these cavities and squeezed into shape and chilled while under pressure. Familiar examples of this technique are typewriter keys or adding machine buttons and dentures as molded by the dental profession.

Printing Operations

For printing, which is a specialized industry, Monsanto Cellulose Nitrate sheets are supplied in a mat finish, and are printed with a special formula ink. The printed sheets are then press polished, which makes the printing permanent and provides a smooth and glossy surface.

This operation consists of placing the printed sheet between highly polished plates and pressing them under heat, then allowing them to chill while under pressure. By this means the polished surface of the plate is reproduced on the cellulose nitrate sheet.

Other Fabrication Facts

Monsanto Cellulose Nitrate can be cemented, as in the case of certain built-up type boxes and spiral and butt weld tubing. This is accomplished by the use of a Monsanto solvent which firmly unites the two surfaces to be cemented. The solvent bites into the two surfaces to be joined and unites them so firmly that the strength of the joint is practically equal to the strength of the original sheet.

The ordinary method of polishing is to use a muslin wheel with a mixture of pumice and water. The piece is then given a high lustre by subsequent operations on other wheels, using rouge. Tool marks are readily polished off by this method.

Another method is to tumble-polish, and by this method certain articles, in shapes that lend themselves to tumble technique, can be given a satisfactory finish. In some cases the tumble-polished pieces are given a final hand polish on a wheel, which, of course, produces a much higher gloss. Dip-polishing in solvents also is used on certain articles.

PROPERTIES OF MONSANTO CELLULOSE NITRATE

MECHANICAL

Specific Gravity	1.35-1.60
Specific Volume, cubic inches per pound	20.5-17.3
Density, grams c.c.	1.35-1.60
Weight per Cubic Inch, (based on specific gravity of 1.4)	0.0507 lb., or 23.0 grams
Refractive Index N_D	1.46-1.50
Tensile Strength, lbs. per sq. in.	6,000-9,000
Elongation, per cent	4-20
Modulus of Elasticity, lbs. per sq. in. x 10^5	2-4
Impact Strength, Charpy (notched) per inch square	3-12
Brinell Hardness, 10 kg. load	10-20
Shrinkage	0-1.4%
Machining Qualities	Very Good

MOLDING PROPERTIES

Type Plastic	Thermoplastic
Molding Quality	Good
Compression Molding Temperature	185-250° F.
Compression Molding Pressure, lbs. sq. in.	100-500
Preforming	Very Good
Tendency to Cold Flow	Very Slight
Molding Methods Applicable	Extrusion, Swaging, Shearing, Blowing—All Very Good
Extruding Quality	Good

THERMAL PROPERTIES

Burning Rate	Rapid
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	3.1-5.1
Specific Heat, calories/1° C./gram	0.34-0.38
Thermal Expansion, 10^{-5} per 1° F.	6.5-8.9
10^{-5} per 1° C.	12.0-16.0
Resistance to Heat, °F. (continuous)	Approximately 140
Softening Point, °F.	160-195
	Decomposes at 272° F. in 30 minutes
Effect of Heat, dry	Discolors on continued heating at 212° F.

ELECTRICAL PROPERTIES

Volume Resistivity ohms/cms (50% R. H.)	(2-30) x 10^{10}
Breakdown Voltage, 60 cycles, volts/mil	600-1,200
Dielectric Constant, 60 cycles	6.9-8.8
Dielectric Constant, 10^6 cycles	6.15
Power Factor, 60 cycles	.062-.144
Power Factor, 10^6 cycles	.074-.097

CHEMICAL PROPERTIES—PHYSICAL PROPERTIES

Odor	None or Camphorous
Taste	Tasteless
Effect of Age	Slight Hardening
Effect of Sunlight	Yellows on Long Exposure
Effect of Ultraviolet Light	Yellows and Decomposes on Extended Exposure
Effect of Weak Mineral Acids	Good Resistance
Effect of Strong Acids	Poor Resistance, Decomposes
Effect of Weak Alkalis	Very Slowly Decomposes
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hours immersion	1.3-2.6%
Effect of Hot Water	Softens, Slight Shrinkage
Effect of Cold Water	None
Moisture Transfer, grams/sq. meter/day/.005"	50-75
Effect on Metal Inserts	None
Solubility: Soluble In—	Alcohols Ketones Esters
Insoluble In—	Aromatic Hydrocarbons Aliphatic Hydrocarbons Mineral Oils Animal Oils Vegetable Oils

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as in many mottles, pearls and ornamental configurations.

Forms: Available in sheets, rods, tubes and special shapes.

PRINTED IN U.S.A.

MONSANTO PLASTICS

PRODUCTS OF MONSANTO CHEMICAL COMPANY
PLASTICS DIVISION • SPRINGFIELD, MASSACHUSETTS

MONSANTO
CAST PHENOLIC RESIN

DATA SHEET 96

MONSANTO CHEMICAL COMPANY · PLASTICS DIVISION
SPRINGFIELD · MASSACHUSETTS

TECHNICAL DATA

MONSANTO CAST PHENOLIC RESIN is a cast phenol-formaldehyde synthetic resin. To produce this jewel-like material, phenol and formaldehyde are placed in a large reaction vessel with a suitable catalyst, wherein they react with the elimination of water.

This process is unique in that it produces a resin which is temporarily fusible and may be drawn from the reaction vessel in a liquid state and cast or poured into molds of intricate shape and design. By casting instead of molding most unusual color effects can be obtained. On curing, with the castings subjected to heat, the resin is converted to an infusible, insoluble material.

Wide Range of Colors

It is extremely hard and durable, yet may be machined readily. It is an especially brilliant and attractive plastic with unusual beauty of color and depth of tone. The quality of this Monsanto Plastic is maintained by subjecting each ingredient to rigid laboratory tests before use.

Monsanto Cast Phenolic Resin is non-inflammable. Belonging to the thermosetting group of plastics, it is practically inert and has an exceedingly low rate of moisture absorption. This material is supplied in an infinite range of colors, almost perfectly simulating onyx, marble and similar effects, and is also supplied in all of the solid colors, ranging from crystal to jet black, in either opaque, translucent or transparent effects.

Versatile in Application

The material is extremely versatile in use, its applications extending from such small units as buttons, dice and dominoes up to such products as clock cases, radio cabinets, furniture and store fixture trim. It has even been used for outdoor signs of large area.

"*Cast* phenolic resin" means that it is poured in liquid form into molds of desired shapes, and then hardened in the mold by being placed in specially built and accurately controlled ovens.

The Casting Process

The casting technique involves the use of lead for the molds. The master pattern or "arbor" is made of highly polished, specially selected alloy steel.

This arbor is immersed in pure lead at accurately controlled temperature. A basket of lead forms around the master arbor when it is withdrawn from the lead pot. This is then cooled and the lead replica is removed from the master arbor and becomes the mold in which the resin is cast.

The master arbor is used over and over again, and such arbors have stood up for many thousands of pieces. The lead mold is used only once, but the lead in the mold is refined and used over again after the finished casting has been removed.

Economy in Special Shapes

Monsanto Cast Phenolic Resin is supplied in sheets, rods and tubes as well as in an endless variety of special shapes, cast as closely as possible to the finished form, to provide the greatest economy in finishing the casting. As an illustration of the range of casting sizes possible, pieces have been cast that weigh as little as one fiftieth of a pound, and on special order castings have been made that weigh as much as one hundred pounds.

The material is finished very much the same as wood or brass. It can be sawed, turned, engraved, drilled, tapped, embossed, formed to a certain extent, and takes an unusually high and lasting glossy finish.

Machining Methods

The usual method of cutting is to use a carborundum disc instead of the ordinary circular saw. In the manufacture of certain products such as buttons, the material is sliced or cut with a very thin knife so that there is no waste of material. Cutting with a carborundum disc is done cold and under water to obtain a smooth surface, while slicing is done with the material warm.

Drilling, routing, bevelling, chamfering and similar operations are done with the ordinary machines except that the machines must operate at high speed. Various cutters are used, but essentially the only requirement is that these cutters must be ground with more clearance than would be used for metal.

For turning in a lathe or screw machine, the setup would be essentially the same as that for brass, with the exception that speed must be regulated to the size of the job in order to obtain the smooth cut. Again the tools should be ground with more than usual clearance. It might be noted that the shavings coming from the tools should be more in ribbon form than otherwise.

Steps in Polishing

The unusually high and lasting finish on Monsanto Cast Phenolic Resin is obtained by first smoothing the casting with a light sanding operation, unless it has been otherwise machined. Then a mixture of pumice and water is used to prepare the surface for polish on a muslin wheel. This is usually followed by a rouging operation, using the same type of wheel with a rouging compound, usually furnished in the form of bricks. Following this, a clean cotton flannel wheel is used to bring up the gloss. Small items are inexpensively polished and finished by tumbling in various special compounds.

If properly polished, the material can be kept glossy over infinitely long periods of time by merely cleaning it with a moist cotton or linen cloth which restores the lustre.

Typical Applications

Because of the scope of color effects and the adaptability of Monsanto Cast Phenolic Resin to a wide variety of shapes with remarkably low arbor costs, the material finds its way into an infinite variety of uses.

Only a few such applications are given, yet they illustrate the range of applications: Small buttons for children's wear, and large and fancy buttons and buckles for dress ornaments; dice, dominoes, poker chips and Mah-Jongg tiles; knife handles, table cutlery handles, percolator handles and gear shift knobs; rings, bracelets and all types of costume jewelry; pen bases, book ends and trophy bases; clock cases ranging from very small boudoir clocks to large upright clocks; radio cabinets; boxes of all sorts; indoor, and in some cases outdoor, signs; decorative trim for furniture and store fixtures, cabinets or trim for vending machines and coin-operated machines.

Wherever color helps to sell, Monsanto Cast Phenolic Resin provides the ideal answer with a material whose color is both *brilliant* and *long-lasting*.

PROPERTIES OF MONSANTO CAST PHENOLIC RESIN

MECHANICAL

Specific Gravity	1.325-1.335
Specific Volume, cubic inches per pound	20.9-20.0
Density, gms/c.c.	1.33
Weight per Cubic Inch (based on specific gravity)	21.8 grams, or 0.048 pound
Refractive Index N_D	1.65-1.68
Tensile Strength, lbs/sq. in.	6,000-12,000
Elongation	Very Slight
Modulus of Elasticity, lbs/sq. in. x 10^5	5-15
Impact Strength, Izod (notched)	0.1-1.5
Brinell Hardness, 25 kg. load	30-45
Machining Qualities	Excellent
Compression Strength, lbs/sq. in.	26,000-33,000
Shrinkage	0-1%

MOLDING PROPERTIES

Type	Thermosetting, Non-moldable

THERMAL PROPERTIES

Burning Rate	Will Not Support Combustion
Thermal Conductivity, 10^{-4} calories per second per sq. cm/1° C. per cm.	3-5
Specific Heat, calories per °C. per gram	0.3 x 0.4
Thermal Expansion, 10^{-5} per 1 °C.	2.8
10^{-5} per 1 °F.	1.55
Resistance to Heat, °F. (continuous)	160
Effect of Heat, Dry	None
Moist	Whitens
Heat Distortion	Above Normal Temperatures

ELECTRICAL PROPERTIES

Volume Resistivity, ohms/cms (50% R. H.)	10^9-10^{14}
Breakdown Voltage, 60 cycles, volts/mil	300-450
Dielectric Constant, 60 cycles	4.5-7.0
10^6 cycles	5.0-7.0
Power Factor, 60 cycles	.025-.200
10^3 cycles	.005-.08
10^6 cycles	.01-.045

CHEMICAL PROPERTIES — PHYSICAL PROPERTIES

Odor	None
Taste	None
Effect of Age	Hardens Slightly
Effect of Sunlight	Yellows Slightly on Exposure. Some Colored Materials Fade.
Effect of Ultraviolet Light	Yellows Slightly on Exposure. Some Colored Materials Fade.
Effect of Weak Acids	None or Slight
Effect of Strong Acids	Decomposed by Oxidizing Acids. Reducing and Organic Acids Have Less Effect.
Effect of Weak Alkalis	Slight to Marked, Depending on Alkalinity
Effect of Strong Alkalis	Decomposes
Water Absorption, 24 hours immersion	.10-.7%
Effect of Hot Water	Softens and Whitens
Effect of Cold Water	None
Effect on Metal Inserts	Inert
Solubility: Insoluble In—	Most Organic Solvents Alcohols Ketones Esters Aromatic Hydrocarbons Aliphatic Hydrocarbons Mineral Oils Animal Oils Vegetable Oils

Color: Available in an extremely wide variety of transparent, crystal, translucent, pastel and opaque colors, as well as in many mottles and ornamental configurations.

Form: Available in sheets, rods, tubes and a very extensive variety of cast shapes and objects.

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MONSANTO PLASTICS

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